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# Technical Men Meet at Atlantic City, N. J.

## Largest Number Ever in Attendance at Meeting of Organization in East Present at Annual Fall Convention of Technical Association of the Pulp and Paper Industry at Atlantic City, N. J. —Technical Papers by Representative Authorities Presented at Various Sessions— Visit Paper Mills and Points of Interest

Nearly 500 members and friends of the Technical Association of the Pulp and Paper Industry met at the Ambassador Hotel, Atlantic City, N. J., on September 18 to 21, 1935, for the fall convention of the association. This was the largest attendance to date of a Technical Association meeting in the East and is a reflection of the growth of the organization during the past year. Excellent weather contributed much to the enjoyment of the convention since some of the social activities included surf bathing, sailing, fishing, and baseball.

### Capable Local Committee

As in the case of all meetings of this type the greatest part of the success is due to the conscientious efforts of the local committee organization. This year the meeting committee met at frequent intervals for many weeks before the convention to discuss details and to apply the best thought to making the meeting well worth attending.

The chairmen of the various committees were as follows: General Chairman, W. R. Maull; Vice Chairman, H. P. Cannon; Administration and Finance Committee, B. M. Thomas; Registration, J. C. Harper; Railroad and Transportation, R. B. Thomas; Program, G. E. Landt; Publicity, E. J. Albert; Entertainment, W. M. Shoemaker; Ladies, Mrs. H. P. Cannon; Trips, C. M. Connor; Recreation, J. C. Dieffenderfer.

### Visit to Hercules Experiment Station

On Wednesday, September 18, the men were taken to Wilmington, Del., to see the Hercules Powder Company and the Paper Makers Chemical Corporation.

Headquarters for Wednesday were established at the Pennsylvania Hotel, Philadelphia, from which point all trips started. Through the courtesy of the Hercules Powder Company a special Pullman train was provided to take about 150 members to Wilmington.

The Experimental Station occupies a commanding hilltop site on a plot of about 300 acres in the rolling Delaware countryside at Hercules, near Wilmington, Del. It consists of a group of thirteen buildings, the central structure being a main laboratory building which is served by a group of semi-plant units, shops and smaller laboratories. Here work is carried on dealing with naval stores, cellulose, nitro-cellulose, papermaking chemicals and explosives operations.

Upon arrival at the station a group photograph was taken in front of the main building, across the front of which was inscribed "Welcome TAPPI" in large letters. A brief address of welcome was made by R. H. Dunham, president, and W. J. Lawrence, vice-president of Hercules Powder Company. Luncheon was then served the visitors and the inspection trip followed.

Following the inspection the special train continued on to North Philadelphia where the party was joined by the ladies and proceeded on to Atlantic City to be met by buses which conducted all to the Ambassador Hotel for the evening's festivities.

The ladies who were in Philadelphia on Wednesday were taken on a trip by bus through Fairmount Park where they visited the historical mansions and had luncheon at Belmont Mansion. Following this they inspected Independence Hall, the Betsy Ross House and Wanamaker's.

The various paper mills in and near Philadelphia kept open house and were visited by a considerable number of members.

In the evening the tired travelers were refreshed by means of a "How-de-do-Party" featured by enjoyable professional entertainment under the direction of Miss Lois Taylor, Mistress of Ceremonies. This was followed by dancing.

### Fundamental Fiber Studies

The paper presentation program on Thursday morning was featured by three papers by outstanding authorities who reported the latest conception in their respective fields. These were George J. Ritter, Ben W. Rowland, and George A. Richter. The meeting was presided over by G. E. Landt of the Continental-Diamond Fibre Company who was introduced by C. C. Heritage, President of the Association.

### Morphology of Cellulose

George J. Ritter of the Forest Products Laboratory outlined the present knowledge regarding the morphology of cellulose fibers. Both generally accepted and controversial views regarding the morphology and some of the attendant physical properties of fibers were discussed. Among these were the interpretation of published results regarding (1) fiber substructures isolated by chemical means: layers, fibrils, fusiforms, spherical units, ellipsoids, dermatosomes,

crystallites and primary valence chain; (2) chemical nature of interfibrillar material; (3) unit cell of the crystal lattice of cellulose; (4) nature of interfiber bonds in paper; (5) internal and external shrinking and swelling of fibers; (6) effect of previous chemical and mechanical treatments on the chemical dissection of fibers; and (7) the effect of beating on some of the physical properties of fibers.

### Cellulose as a Colloid

Ben W. Rowland of the Institute of Paper Chemistry presented a survey of recent work on selected topics concerning the colloidal behavior of cellulose as related to technical problems of paper making. Among the most important of the natural aging changes in cellulose is that of gradual desiccation or loss of moisture. It is likely that in the future inhibitors will be available that will retard the aging of paper and probably accelerators will be used to speed up the rate of hydration, in fact, it is possible that chemical hydration may take the place in whole or part of mechanical hydration. By proper surface orientation it is possible that a completely opaque sheet of paper will be made without the use of mineral filler.

### Pulping Treatment and Fiber Properties

A paper prepared by George A. Richter of the Brown Company, Berlin, N. H., was presented by W. B. Van Arsdel of that company. In this paper it was pointed out that a few years ago there were but four major types of pulp available, the properties of which were limited in scope. Because of research there are five or more new types of pulp which have additional characteristics and consequently have extended the range of sheet properties to a considerable extent.

### Thursday Luncheon Program

Clark C. Heritage of the Oxford Paper Company and President of TAPPI was the speaker at the Thursday Luncheon. Mr. Heritage outlined the various activities of the Technical Association and reported on the Executive Committee activities.

Some motion pictures of "George Washington's Railroad" were shown by the Chesapeake and Ohio Railroad.

### Golf Tournament

The annual fall meeting golf tournament was held at the Country Club of Atlantic City (Northfield). The prize for low gross was won by A. J. Campbell of the American Cyanamid and Chemical Company. The low net prize was won by E. J. Tewksbury of Stowe-Woodward, Inc. Second low gross was tied by Tom Stirling and Bud Mueller of Paper Makers Chemical Corporation, and second low net by F. K. Becker of Bird Machine Company.

The Thursday program for ladies consisted of surf bathing and a bridge tournament, the latter at the Seaview Country Club where luncheon also was served.

### Gay Nineties Party

A delightful feature of the meeting was the Gay Nineties

PICTURE OF BANQUET TAKEN AT FALL CONVENTION OF THE TECHNICAL ASSOCIATION OF T[illegible]LP AND

Dinner Party. Everyone present was dressed in the style prevailing at the start of the century. In addition to professional talent two interesting performances were on the program. The Delaware Valley TAPPI Section presented a one-act play, "Saved or Triumphant Redemption," with heroes, villains, etc., and the New England TAPPI presented an amateur night show. The make-up almost entirely obliterated the identity of the actors.

### Fundamental Operating Problems

The formal presentation of papers on Friday morning featured contributions dealing with practical application of fundamental *principles* by R. H. Doughty, A. M. Lund and W. K. Farr.

### Sheet Structure

R. H. Doughty of the Fitchburg Paper Company presented a paper entitled "Some Effects of Mechanical Treatment of Fibers on Sheet Structure." In this paper it is pointed out that mechanical treatment can do just three things to fibers, it can increase their flexibility, split and shorten them. The present means of recognizing these effects are by microscopic measurement, screen analysis and freeness. Processing the fibers greatly increases the shrinkage at any solid fraction. The change is more rapid early in the processing.

A. M. Lund of the Mazer Paper Company discussed the principles governing the arrangement of fibers on the fourdrinier wire. The behavior of fibers of different dimensions and flexibility during the formation of a sheet was shown to be a problem of hydraulics. Fiber arrangement is dependent on what takes place at this stage.

### The Formation of Cellulose Membranes

An outstanding feature of the meeting was a paper by Mrs. Wanda K. Farr of the Boyce-Thompson Institute for Plant Research, Yonkers, N. Y., who exhibited a number of photomicrographs specially stained and made with the aid of polarized light in which the cellulose membrane in process of formation is shown. This paper was not only applauded but was actually cheered, the first time that such an expression was given during any TAPPI meeting.

### Harry P. Carruth Luncheon Speaker

At the Friday luncheon H. P. Carruth, President of Dill & Collins, Inc., was the speaker. His subject was "An Opportunity for the Technical Man." Technology plays a part in operation, merchandising and research. Management must consider and correlate all of these factors. The technical man can best serve his company in doing his work with optimum economic conditions in mind. For instance an improvement, saving $10,000 per year with no capital investment is a greater business achievement than one of equal return involving the investment of capital. The invention of a new product which fits the manufacturing and merchandising set-up of the company is far more valuable to that company than one which is not fitted to make or sell. The method of utilizing profitably some

P AND PAPER INDUSTRY, AMBASSADOR HOTEL, ATLANTIC CITY, N. J., SEPTEMBER 20, 1935.

minor by-product of the plant is more valuable to that company than a much greater improvement applicable to some other fellow's business. Therefore technical men should study their own business, search out materials, methods, products, for it will show financial advantage.

### Woodlands Movies

Roger J. Egan of Bulkley, Dunton & Co., exhibited motion pictures showing the methods of logging as practiced in Canada, Newfoundland, Wisconsin, and on the Pacific Coast. He was assisted with "sound effects" by C. H. Champion of R. T. Vanderbilt Company.

### Recreational Activities

Friday afternoon was devoted to outdoor recreation activities including a sail along the beachfront, deep sea fishing and a baseball game on the beach. An all-Eastern team made up of Cannon, Bates, Dickson, Stroud, Dutney, Stirling, Hemphill, Donaldson and Boyd defeated (8 to 7) an all-Western team made up of Simmons, Smiley, Hinckle, Underdown, Beck, Snyder, Magill, Hausman, R. B. Thomas. Every player was dressed in Hawaiian costume.

The ladies had luncheon at the famous Hackney restaurant after which they went for a sailboat ride.

### Karl T. Compton Speaks at Banquet

The annual fall meeting banquet which is always an important feature of the meeting had for its chief speaker Karl T. Compton, president of the Massachusetts Institute of Technology. Dr. Compton made a plea for the appreciation of pure science research as contrasted with applied research. He pointed out a number of examples of how pure science has been the basis of great industrial developments.

G. E. Landt was the toastmaster during this banquet. President Heritage presented, on behalf of the National Association, a large banner inscribed "Delaware Valley TAPPI," to that Section which was represented by H. P. Cannon, Chairman of the Section. In his remarks Mr. Cannon outlined the pioneer history of the paper industry in the Delaware Valley.

### Miscellaneous Papers

J. d'A. Clark was the chairman of the Saturday morning meeting at which a number of miscellaneous papers were read.

### Pulp and Paper Drying

D. W. McCready, assistant professor of chemical engineering at the University of Michigan, presented two papers on "Drying of Pulp and Paper II, The Effects of the Principal Variables on the Rate of Air Drying, and III "The Mechanism of Drying Pulp Slabs on Heated Surfaces." The variables considered were thickness, density and porosity of the slab and the temperature, humidity and velocity of the air stream. The factors that have the greatest influence on the rate of drying of paper are the temperature of the hot surface, the thickness of the paper and the use of a drier felt. The temperature of the drying air has little effect on the rate of drying, as most of the heat required for the drying process is supplied from the hot surface. Changing the relative humidity of the air has little effect on the rate of drying providing the difference between the hot surface and drying air temperature is large.

### White Water Loss Tolerances

C. M. Baker of the American Paper and Pulp Association pointed out that standards or objectives limiting white water losses are desirable but adoption of arbitrary standards by state officials, limiting stream polution is not feasible because of variation in grades and operating conditions in the mill, and in stream characteristics and requirements. The water consumption for a paper mill is recommended to be 20,000 gallons per ton of product and the fiber loss should be less than 1 per cent of production. The loss in per cent of filler furnish for book paper mills should not exceed 30 per cent.

### Color Analysis

Joseph Razek of the Randal Morgan Laboratory of Physics, University of Pennsylvania, gave a general outline of the spectrophotometric method of color analysis, together with a method of reduction to trilinear coordinates in accordance with the procedure suggested by the International Committee on Illumination. Methods of calculating whiteness and other optical units were discussed.

### Temperature and Consistency of Ground Wood

E. R. Schafer and J. C. Pew, engineers of the Forest Products Laboratory, Madison, Wis., reported on experiments made in which white spruce and loblolly pine were ground at various temperatures and consistencies on several types of stone surfaces under carefully controlled conditions. High temperatures favor the grinding process provided excessive pulp consistencies are prevented by the use of warm shower water. The grinding rate is increased, a decrease in power consumption, an increase in the strength of the pulp and an increase in fiber length and freeness. Under 4 per cent consistencies there is no change in the color of the pulp.

### Testing Pulp Bleachability

A paper contributed by David Johansson of the Swedish Pulp Company, Ostrand, Sweden, who was not present, outlined methods of determining the cooking degree and strength properties used in various countries. The lignin content of pulp is a measure of the degree of cooking. Test methods utilizing the oxidizing effect of gaseous chlorine, permanganate and bleaching powder are recommended. A procedure that should lead to international acceptance was described.

### Retention of Fillers

William R. Willets of the Titanium Pigment Company reported on laboratory investigations on the retention of mineral fillers in paper. The factors influencing retention that are important include alum, temperature, dilution, hydration and basis weight. Particle size has much less influence than these. Retention was increased with increased dilution, increased temperature, increased basis weight, hydration and by increasing the alum up to 3 per cent. Rosin size when used with alum increases the retention.

### Wage Rates

John P. Hagenauer of the American Paper and Pulp Association outlined the various wage rate theories and explained their advantages and disadvantages. A survey of existing wage rates in the industry showed that there is a reasonable close conformance to the limits found by the ratios for highly skilled and low skill occupations. Considerable variations from the limits set is very noticeable for intermediate occupations. This situation shows that wages for highly skilled operators are usually carefully watched and controlled while those for intermediate operations are more haphazardly set or adjusted. Technological unemployment has been shown to increase the hourly rates but has tended to draw the line of demarcation more distinctly between skilled and unskilled labor and has created a class of employes highly skilled in certain specific occupations.

GROUP PICTURE OF TAPPI TAKEN AT HERCULES POWDER EXPERIMENTAL STATION.

S. G. Wells of Combined Locks Paper Company submitted a paper to be read by title on "The Utilization of Waste Liquor." This was received too late for the meeting but will be published in the near future. This paper deals with recent refinements in the Paulson process. Among these are the use of two screw presses in series to remove liquor from the pulp taken from the blow pit without dilution and the return of the effluent from the second press to the acid system, thereby eliminating most of the waste.

**Final Luncheon**

The speaker at the Saturday luncheon was Charles W. Boyce, Executive Secretary of the American Paper and Pulp Association, who outlined the importance of forest operation to pulp manufacture, and the trends that may be expected, especially as these may be influenced by Southern and Northwestern developments.

The meeting was fittingly adjourned with remarks by President Heritage and W. R. Maull, General Chairman.

**Exhibits**

An interesting addition to the meeting was the exhibits by the following companies: American Brass Company, Cameron Machine Company, Chromium Corporation of America, Continental-Diamond Fibre Company, Downingtown Manufacturing Company, Edgar Bros. Company, R. Fuess, Inc., General Electric Company, Ingersoll-Rand Company, Johns-Manville, Paper and Industrial Appliances, and Testing Machines, Inc.

**Papers in Technical Section**

Some of the papers presented at the convention are printed in this week's issue of the Technical Section on page 63.

**Among Those Present**

Among those present were the following:

Mr. and Mrs. Allen Abrams, Marathon Paper Mills, Rothchild, Wis.; Mr. and Mrs. E. J. Albert, Thwing Instrument Co., Philadelphia, Pa.; W. J. Alford, Thames Board Mill, London, England; C. G. Albert, Edgar Bros., Metuchen, N. J.; A. L. Allen, Chromium Corp. of America, New York City; S. Anderson, Hooker Electrochemical Co., New York City; Mr. and Mrs. W. H. Artz, Westinghouse Elec. and Mfg. Co., E. Pittsburgh, Pa.; L. C. Anderson, Ontario Paper Co., Thorold, Ont.

Mr. and Mrs. H. T. Baughman, West Virginia Pulp and Paper Co., Williamsburg, Pa.; W. E. Bailey, Container Corp. of America, Manayunk, Pa.; R. W. Ball, Krebs Pigment and Color Corp., Newport, Del.; C. L. Bachelder, Paper Maker Chemical Corp., Kalamazoo, Mich.; A. S. Bailey, Du Pont, Providence, R. I.; C. M. Baker, American Paper & Pulp Association, Madison, Wis.; R. S. Barr, Krebs Pigment and Color Corp., Philadelphia, Pa.; A. J. Barea, Patterson Parchment Paper Co., Modena, Pa.; C. P. Barker, Container Corporation of America, Chicago, Ill.; Mr. and Mrs. P. S. Barnhart, Westfield River Paper Co.; Riley M. Bates, Thomas M. Royal & Co., Philadelphia, Pa.; F. C. Beadle, West Virginia Pulp and Paper Co., Mechanicville, N. Y.; Mr. and Mrs. J. B. Beck, E. B. Eddy Co., Hull, Can.; Mr. and Mrs. F. K. Becker, Bird Machine Co., South Walpole, Mass.; H. L. Becker, Agasote Mill Board, Trenton, N. J.; Mr. and Mrs. L. C. H. Beighey, Hammermill Paper Co., Erie, Pa.; Mr. and Mrs. C. L. Bidwell, Jr., Riegel Paper Corp., Milford, N. J.; H. O. Bing, Beloit Iron Works, Beloit, Wis. Miss S. Blair, T.A.P.P.I., New York; C. W. Boley, Paper Makers Chemical Co., New Orleans, La.; E. Y. Burckhalter, American Cyanamid & Chemical Corp., New York; L. M. Booth, Booth Chemical Co., Elizabeth, N. J.; Mr. and Mrs. A. E. Boyd, F. C. Huyck & Sons, Albany, N. Y.; M. Brooks, Raffold Process Corp., Andover, Mass.; W. B. Brendlinger, Ingersoll-Rand Co., New York City; J. N. Booth, Huron Milling Co.; H. W. Brewster, American Brass Co., Waterbury, Conn.; Mr. and Mrs. J. H. Brougham, Penn Fibre Board Co., York, Pa.; W. J. Burke, General Dyestuffs Corp., New York City; Mr. and Mrs. H. H. Burrows, Manhattan Rubber Co., Passaic, N. J.; W. E. B. Baker, New York & Pennsylvania Co., Lock Haven, Pa.; Philip Becht, Waldorf Pulp Co., Berlin, Germany; Leroy Benge, National Vulcanized Fibre Co., Yorklyn, Del.; H. G. Bickley, West Virginia Pulp & Paper Co., Williamsburg, Pa.

Mr. and Mrs. A. E. Cadman and party, Canadian Pulp and Paper Association, Montreal; Mr. and Mrs. O. W. Callighan, Edgar Bros., Co., Kalamazoo, Mich.; Mr. and Mrs. H. P. Cannon, Container Corp. of America, Manayunk, Pa.; A. G. Cardwell, Krebs Pigment and Color Corp., Newark, N. J.; F. Casciani, Electric Bleaching Gas Co., Niagara Falls, N. Y.; Mr. and Mrs. C. H. Champion, R. T. Vanderbilt Company, New York City; Mr. and Mrs. W. A. Chilson, U. S. Forest Products Laboratory, Madison, Wis.; J. N. Chesnutt, McDowell Paper Mills, Philadelphia, Pa.; Mr. and Mrs. J. d'A. Clark, Scott Paper Co., Chester, Pa.; C. L. Clark, Nash Engineering Co., New York, N. Y.; Samuel Clayman, Clinton Co., Philadelphia, Pa.; Miss R. M. Cobb, Lowe Paper Co., Ridgefield, N. J.; N. A. Cochran, Container Corp. of America, Chicago; A. A. Coffin, Titanium Pigment Co., New York City; Mr. and Mrs. Grellet W. Collins, Scarsdale, N. Y.; P. A. Collins, Warren Steam Pump Co., Boston, Mass.; G. Collins, Dill & Collins, Inc., Philadelphia, Pa.; C. E. Connor, Valley Forge Laboratories, Paoli, Pa.; Mr. and Mrs. A. M.

Cooper, Westinghouse Electric and Mfg. Co., Philadelphia, Pa.; John Cornell, The Paper Mill, New York City; N. C. Cooper, Du Pont Co., Wilmington, Del.; O. L. Coward, General Electric Co., Philadelphia, Pa.; Lester W. Crouse, Penick & Ford, Ltd., Inc., Springfield, Mass.; H. A. Crown, Corn Products Refining Co., New York City; C. E. Curran, U. S. Forest Products Laboratory, Madison, Wis.; Arthur Campbell, American Cyanamid and Chemical Corp. New York City; M. P. Chaplin, Chaplin Corp., Portland, Maine; A. B. Clark, Ross Eng. Corp., New York City; Mr. and Mrs. O. C. Cordes, Dowingtown Mfg. Co., Downingtown, Pa.

A. Davis, Canadian International Paper Co., Temiskaming, Ont., Can.; V. S. Denison, Beloit Iron Works, Beloit, Wis.; Geo. H. Detwiler, Heller & Merz, Philadelphia, Pa.; J. C. Dickson, Jr., R. C. Vanderbilt Co., N. Y.; Mr. and Mrs. J. C. Dieffenderfer & Son, Paper Makers Chemical Corp., Easton, Pa.; L. A. Dix, Paper and Industrial Appliances, New York City; Mr. and Mrs. Jas. Donaldson, Stora Kopparberg Corp.; R. H. Doughty, Fitchburg Paper Co., Fitchburg, Mass.; Mr. and Mrs. Wm. T. Doyle, Sturtevant Mill Co., Boston, Mass.; A. C. Dreshfield, Paper Makers Chemical Corp., Kalamazoo, Mich.; Pierre Drewsen, Hinde and Dauch Paper Co., Sandusky, Ohio; Mr. and Mrs. J. R. Dufford, Patterson Parchment Paper Co., Bristol, Pa.; G. F. Durand, Port Huron Sulphite and Paper Co., Port Huron, Mich.; C. P. Dyer, Merrimac Chemical Co., Boston, Mass.; Mr. and Mrs. J. A. DeCew, Process Engineers, Inc., Mt. Vernon, N. Y.; G. V. Dutney, Johns Manville Co., Philadelphia, Pa.

Miss Annette L. Elliott, Wilmington, Del.; Mr. and Mrs. Jacob Edge, Downingtown Mfg. Co., Downingtown, Pa.; Mr. and Mrs. R. J. Egan, Buckley, Dunton & Co., Chicago; Mr. and Mrs. Ivan Ekholm, National Amiline and Chemical Co., New York City; George A. Eagert, Dilts Machine Works, Fulton, N. Y.; Earnest Erickson, Lagerloef Trading Co., New York City; Mr. and Mrs. Frank W. Egan, John Waldron Corp., New York City; G. A. Engart.

A. E. H. Fair, Alliance Paper Mills, St. Catharines, Ont.; L. E. Fitzgerald, Paper Makers Chemical Corp., Kalamazoo, Mich.; J. M. Fleming, Metro-Vickers Electro Co., Manchester, Eng.; A. W. Foley, Hummell Rose Fibre Co., Hopewell, Va.; W. L. Foote, B. F. Perkins & Sons, Inc.; J. A. Foxgrover, Paper Makers Chemical Corp. Kalamazoo, Mich.; Mr. and Mrs. Frank Frampton, Hopper Paper Co., Taylorsville, Ill.; R. D. Freeman, Dow Chemical Co., Midland, Mich.; Mr. and Mrs. J. H. Fritz, National Oil Products Co., Harrison, N. J.; S. W. Fletcher, Ross Engineering Co., New York.

R. A. Gormley, Corn Products Refining Co., New York City; Mr. and Mrs. W. N. Greer, Leeds & Northrup, Philadelphia; R. C. Griffin, A. D. Little, Inc., Cambridge, Mass.; E. A. Georgi, Hercules Powder Co., Wilmington, Del.; Mr. L. A. Gilbertson, Dill & Collins, Philadelphia, Pa.; Emerson N. Glauner, Downingtown Mfg. Co., Downingtown, Pa.; Mr. and Mrs. Otto J. Goeppinger, Woodside, N. Y.; A. C. Goetz, Eagle-Picher Sales Co., New York City; E. R. Granger, Chromium Corp. of America, Waterbury, Conn.

J. P. Hagenauer, American Paper and Pulp Association, New York City; Miss Lois V. Hans, Pettingill, Inc., New York City; Miss Bessie A. Harpell, Pulp and Paper Magazine of Canada, Gardenvale, P. Q.; Mrs. J. J. Harpell, Pulp and Paper Magazine of Canada; Mr. and Mrs. J. C. Harper, Jr.; West Jersey Paper Co., Camden, N. J.; Ray Harter, R. T. Vanderbilt Corp., Philadelphia, Pa.; S. Hausman, Congoleum Nairn Co., Cedarhurst, N. J.; Mr. and Mrs. J. J. Hearn, Container Corp. of America, Philadelphia, Pa.; Olef H. Hedstrom, Hartford City Paper Co., Hartford City, Ind.; G. Heidrich, Wallace & Tiernan, Newark, N. J.; J. W. Hemphill, Johns-Manville Corp., New York City; Mr. and Mrs. C. C. Heritage, Oxford Paper Company, Rumford, Me.; Mr. and Mrs. S. M. Hesser, Hinde & Dauch Paper Co., Gloucester, N. J.; J. M. Hibbs, Paper Makers Chemical Co., Burlington, Ont.; J. D. Haskell, Dilts Machine Works, Fulton, N. Y.; F. D. Helms, Du Pont Co., Wilmington, Del.; Edw. O. Hemstrect, Carborundum Co., Niagara Falls, N. Y.; Hubert F. Hoffman, General Dyestuff Corp., Philadelphia, Pa.; Chas. H. Herty, Pulp and Paper Labortories, Savannah, Ga.; Mr. and Mrs. W. R. Huey, Continental-Diamond Fibre Company, Newark, Del.; Mr. and Mrs. H. S. Hill, Price Bros., Quebec; E. S. Hinman, Penn Fibre Board Corp., York, Pa.; C. W. Hoffman, Riegel Paper Corp., Milford, N. J.; Harold Holden, Paper Makers Chemical Co., Boston, Mass.; J. H. Hubel, Canadian Chemicals, Inc.; J. E. Hughes, Krebs Pigment and Color Corp., Newark, N. J.; Mr. and Mrs. C. L. M. Hellstrom, Paper Mill Equipment, Ltd., Montreal, P. Q.

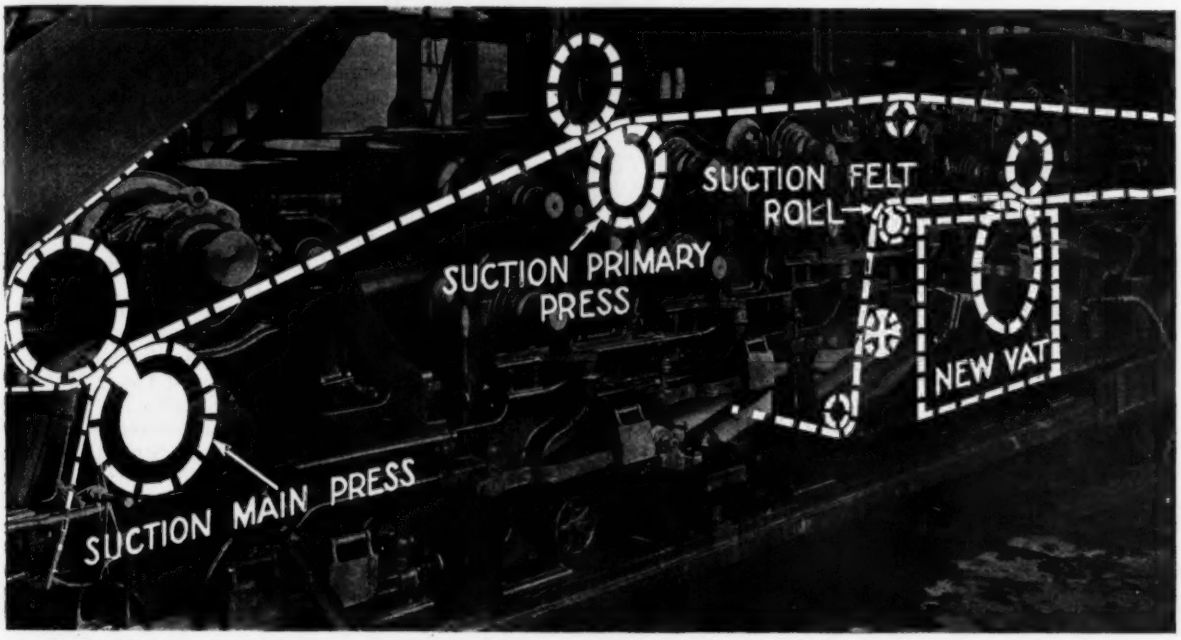
Mr. and Mrs. C. C. Irving, S. D. Warren Co., Cumberland Mills, Me.; T. H. Ireland, Crane Co., Chicago.

Mr. and Mrs. Valdemar Jacobsen, National Aniline Co., Philadelphia; Wm. C. Jay, Sanitary Products Corp., Philadelphia, Pa.; Geo. Jayme, Canadian International Paper Co., Hawkesbury, Ont.; Gust. Johanson, American Locomotive Co., Dunkirk, N. Y.; Roy B. Johns, Freeport Sulphur Co., New York City.

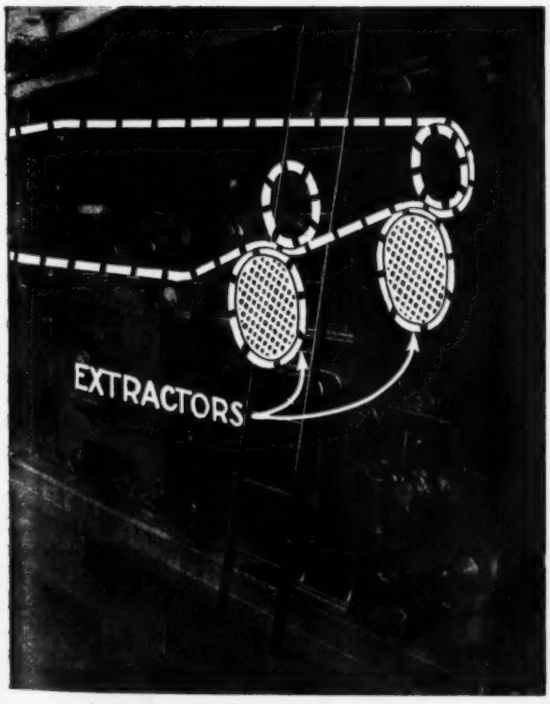
Mr. and Mrs. H. E. Karberg, Alliance Paper Mills, Merritton, Ont.; Horace Keesey, Schmidt & Ault Paper Co., York, Pa.; Mr. and Mrs. R. S. Kellogg, News Print Service Bureau, New York City; C. H. Kent, Paper Makers Chemical Corp., Holyoke, Mass.; A. J. Kennedy, Sandy Hill Iron and Brass, Hudson Falls, N. Y.; W. S. Kidd, E. B. Eddy Co., Hull, P. Q.; Miss H. U. Kiely, American Writing Paper Co., Holyoke, Mass.; J. T. Kemp, American Brass Co., Waterbury, Conn.; C. E. Kinney, Hercules Powder Co., Wilmington, Del.; Mr. and Mrs. F. H. Knowlton, Staley Sales Corp., Decatur, Ill.; Paul Koenig, P. H. Glatfelter Co., Spring Grove, Pa.; M. M. Kennedy, Penick & Ford Ltd., New York City; Kenneth T. King, Du Pont Co., Wilmington, Del.; R. P. Kite, The Dorr Co., N. Y.; Ralph W. Kumler, Bennett, Inc., Wilmington, Del.

Dr. and Mrs. G. H. Landt, Continental Diamond Fibre Company, Bridgeport, Pa.; O. F. Lane, Krebs Pigment & Color Corp., Newark, N. J.; F. L. La Que, International Nickel Company, New York; T. E. Layng, Container Corp., Manayunk, Pa.; W. J. Lawrence, Paper Makers Chemical Corp., Kalamazoo, Mich.; J. A. Lee, Chem. & Met., New York City; F. Libby, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.; J. S. Little, Western Electric Co., Kearney, N. J.; H. S. Leonard, Merrimac Chemical Co., Boston, Mass.; P. E. Linchwhite, Ingersoll-Rand Co., New York City; M. London, Lagerloef Trading Co., New York City; A. B. Loomis, Ingersoll Rand Co., New York City; F. H. Lovenberg, Mathieson Alkali Works, Providence, R. I.; A. J. Luettgen, P. H. Glatfelter Co., Spring Grove, Pa.; Mr. and Mrs. A. J. Luth, Nekoosa-Edwards Paper Co., Port Edwards, Wis.; Larry Lynd, R. T. Vanderbilt Co., New York City; V. E. Lysaght, Wilson Mech. Inst. Co., New York City; E. T. Lang, American Brass Co., Waterbury, Conn.; N. J. Larsen, Albany Felt Co., Albany, N. Y.; F. H. Leonard,

# DOWNINGTOWN




## Squeeze Roll Section Eliminated by Duo-Dehydration

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No Board Machine is Modern *Without* DUO-DEHYDRATION

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A. W. Nickerson, 501 Fifth Avenue, New York City; W. A. Nivling, Huron Milling Co., Boston, Mass.

J. W. Outerson, Paterson Parchment Paper Co., Paterson, N. J.; H. K. Owen, Johns Manville Corp., Philadelphia, Pa.; Geo. W. Oliphant, Castle & Overton, New York City.

J. L. Parsons, Hammermill Paper Co., Erie, Pa.; C. E. Peterson, Riegel Paper Corp., Riegelsville, N. J.; Mr. and Mrs. E. Peterson, B. F. Goodrich Co., Akron, Ohio; J. C. Pew, Forest Products Laboratory, Madison, Wis.; G. P. Prather, Dilts Machine Co., Fulton, N. Y.; Mr. and Mrs. R. P. Price, Hammermill Paper Co., Erie, Pa.; N. R. Pike, Nulomoline Co., New York City; Henry Piquet, MacAndrews & Forbes Co., Camden, N. J.

Robert G. Quinn, Glens Falls, N. Y.

J. G. Rearick, Warren Steam Pump Co., Warren, Mass.; A. E. Regnier, Paper Makers Chemical Corp., Stoneham, Mass.; Mr. and Mrs. S. D. Reynolds, Container Corp. of America, Philadelphia, Pa.; George J. Ritter, Forest Products Laboratory, Madison, Wis.; Mr. and Mrs. C. W. Rivise, Philadelphia, Pa.; Jay Robinson, National Vulcanized Fibre Co., Wilmington, Del.; B. W. Rowland, Institute of Paper Chemistry, Appleton, Wis.; H. J. Rowley, Anglo-Canadian Pulp and Paper Mills, Quebec, P. Q.; J. W. Rains, Lindsey Wire Weaving Co., Philadelphia; Mr. and Mrs. Homer M. Rice, Du Pont, Watertown, N. Y.; C. P. Robinson, The Borregaard Co., Inc., New York City; Chas. S. Rowe, Du Pont Co., Wilmington, Del.; Mr. and Mrs. Jos. Rossman, Marathon Paper Mills Co., Rothschild, Wis.

C. A. Sankey, Ontario Paper Co., Thorold, Ont.; W. L. Savell, Mathieson Alkali Works, New York City; Miss E. A. Schanz, R. T. Vanderbilt Co., New York City; Hugo Schapiro, Ohio Box Board Co., Wadsworth, Ohio; Mr. and Mrs. J. Schuman, Cameron Machine Co., Brooklyn, N. Y.; M. E. Schleimer, Testing Machines, Inc., New York; Mr. and Mrs. J. Carl Schmidt, Du Pont Co., Philadelphia, Pa.; H. Z. Schiewind, Testing Machines Inc., New York City; Mr. and Mrs. A. M. Shoemaker, National Vulcanized Fibre Co., Yorklyn, Del.; Mr. and Mrs. Schoonmaker, Titanium Pigment Co., Philadelphia, Pa.; Harlan Scott, Pacific Pulp and Paper Industry, Seattle, Wash.; B. W. Scribner, Bureau of Standards, Washington, D. C.; M. B. Shaw, Bureau of Standards, Washington, D. C.; A. L. Sherwood, Sutherland Paper Co., Kalamazoo, Mich.; T. F. Shuman, American Cyanamid & Chemical Corp., Kalamazoo, Mich.; R. H. Simmons, U. S. Government Printing Office, Washington, D. C.; R. Skagerberg, Minneapolis-Honeywell Co., Minneapolis, Minn.; Roscoe H. Smith, Reliance Elec. & Engr. Co., Cleveland, Ohio; A. O. Spierling, Hammermill Paper Co., Erie, Pa.; L. Starck, Wilson Wire Works, Kearney, N. J.; B. K. Steadman, Standard Paper Mfg. Co., Richmond, Va.; Mr. and Mrs. J. N. Stephenson, Pulp and Paper Magazine of Canada, Gardenvale, Que.; Fred Stiegler, National Vulcanized Fibre, Wilmington, Del.; T. L. Stirling, Paper Makers Chemical Co., Holyoke, Mass.; W. D. Stroud, F. C. Huyck & Sons, Boston, Mass.; Miss E. Sullivan, Holyoke, Mass.; L. T. Summers, Port Huron Sulphite Paper Co., Port Huron, Mich.; D. Manson Sutherland, Trenton, N. J.; Mr. and Mrs. Geo. Schwartz, Du Pont Co., Wilmington, Del.; E. Smiley, Edwin Smiley Co.; F. A. Soderberg, General Dyestuff Co., New York City; Geo. K. Spence, Castanea Paper Co., Johnsonburg, Pa.; F. A. Steele, New Jersey Zinc Co., Palmerton, Pa.; C. C. Stewart, C. C. Stewart Paper Co., Philadelphia, Pa.; F. A. Strovnik, Bennett Inc., Cambridge, Mass.; Dr. and Mrs. H. C. Schwalbe, Dill & Collins, Philadelphia, Pa.; Wm. H. Savery, Harper's Ferry, W. Va.; John Schiber, St. Regis Paper Co., Deferiet, N. Y.; Chas. A. Shubert, Dill & Collins, Philadelphia, Pa.

Mr. and Mrs. K. N. Thorsen, Central Paper Co., Muskegon, Mich.; Mr. and Mrs. B. M. Thomas, Container Corporation, Manayunk, Pa.; Mr. and Mrs. R. B. Thomas, Dill & Collins Inc., Philadelphia, Pa.; John Traquair, Mead Corp., Chillicothe, Ohio; E. A. Turner, International Nickel, New York City; Mrs. Louis Taylor, Wilmington, Del.; Mr. and Mrs. F. P. Thornton, Stowe-Woodward, Inc., New York City; E. L. Tewksbury, Stowe-Woodward, Inc., New York City.

Mr. and Mrs. R. H. Underdown, American Dyewood Co., N. Y. Color & Chem. Co., Philadelphia, Pa.

W. B. Van Arsdel, Brown Co., Berlin, N. H.; D. L. Vanderburg, Staley Sales Corp., Decatur, Ill.; Mr. and Mrs. C. C. Van Stry; J. W. Voller, Dill & Collins, Inc., Philadelphia, Pa.

J. D. Wallace, Black-Clawson Co., Hamilton, Ohio; T. T. Watson, Lukens Steel Co., Coatesville, Pa.; James Watt, Johns-Manville Corp., Philadelphia, Pa.; A. E. Waugh, U. S. Rubber Products, Inc.; N. W. Webb, Eastwood-Nealley Corp., Belleville, N. J.; Mr. and Mrs. R. F. Wehmer, Electrical Testing Lab., New York City; Curl Weil, Paper and Industrial Appliances Co., New York City; Mr. and Mrs. J. Westergaard, Atterbury Bros., New York City; H. E. Weston, Paper Industry, Chicago; J. N. Wheeler, Krebs Pigment and Color Corp., Philadelphia, Pa.; D. A. Wickerham; A. W. Wickham, MacAndrews & Forbes Co., Camden, N. J.; Fredrick Wierk, Johnson & Wierk, New York City; Mrs. M. Wierk; Mr. and Mrs. W. R. Willets, Titanium Pigment Co., Brooklyn, N. Y.;

Dilts-

We place at your disposal sixty-eight years of practical experience in the building of dependable paper making equipment.

Our experience can help you in modernizing and improving your mill.

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MACHINE WORKS, Inc. FULTON, N.Y.

Mr. and Mrs. H. M. Wilson, H. M. Wilson Co., Philadelphia, Pa.; F. E. Winslow, General Electric Company, Philadelphia, Pa.; Mr. and Mrs. Jack F. Wright, National Aniline & Chemical Co., Boston, Mass.; Mr. and Mrs. Jess G. Wright, A. M. Meincke & Son, Inc., Chicago; W. F. Walton, Chromium Corp. of America, New York City; Wm. J. Weed, Electro Bleaching Gas Co., New York City; E. W. Wennberg, Continental-Diamond Fibre Co., Bridgeport, Pa.

A. Yraola, Hinde & Dauch Paper Co., Toronto, Can.; F. W. Young, Oliver-United Filters, New York City.

## To Start Dayton Envelope Co.

[FROM OUR REGULAR CORRESPONDENT]

DAYTON, OHIO, September 23, 1935—A new $1,000,000 industry for Dayton was announced Thursday by Maxwell Howard, president of the Aetna Paper Company. The new company, to be known as the Dayton Envelope Company, will be located in the Naval Ordnance building on Chapel street, formerly occupied by the Coffield Washing Machine Company.

Officers of the organization include: Maxwell Howard, president; Ward R. Howard, vice president; H. H. Hoffman, secretary, and Howell H. Howard, treasurer and general manager.

Operation of the company, with a force of possibly 400 employees, is expected to start within the next few months, according to officials of the company.

The company, according to Mr. Howard, will manufacture a complete line of envelopes which will be distributed through the wholesale paper merchants who are already agents of the Aetna Paper Company and allied mills.

According to the announcement the Aetna Paper Company and its allied mills, the Howard Paper Company, of Urbana, Ohio, and the Maxwell Paper Company, of Franklin, Ohio, have joined a new enterprise for Dayton in the incorporation of the Dayton Envelope Company with a paid in cash capital stock of $1,000,000. Incorporation papers for the company are now in the course of preparation.

The company has purchased the entire machinery and equipment of the former Centralia Envelope Company whose plant occupied an entire city block in Centralia, Illinois. This equipment will be supplemented by new and up-to-date machinery making the new local company one of the most modern and high speed plants for producing commercial envelopes in the country.

## Testing Machines, Inc. Exhibit

Testing Machines, Inc., 460 West 34th Street, New York, at the fall convention of the Technical Association of the Pulp and Paper Industry, Atlantic City, N. J., September 18 to 21, displayed the well known Schopper standard paper testers. The new improved Schopper-Riegler beating and freeness (slowness) tester with the new automatic lifting device, doing away with all human element was of great interest to the many users of the former and original model. The new Schopper 1/10,000" micrometer with the improved adjustment and easy reading dial also attracted considerable attention. Other Schopper testers displayed were the standard folding endurance tester, with jewel bearings, tensile, bursting, bulking and impact tear tester.

Those who already have old testers were informed that they should be sent in for necessary genuine new parts and recalibration.

## Improved Open Back Screen Plate

The Chromium Corporation of America states that twenty thousand screen plates have been Crodon-plated and believes that long-time performance records have conclusively proved their multiple advantages and substantial economies. Worn, rough and inaccurate slots invariably result from normal wear of ordinary plates. Crodon provides a permanently hard, durable protection against wear and corrosion. Exact precision of slot dimensions is accurately maintained. Finer slot sizes are possible with Crodon; not only is cleaner, finer paper obtained, but it is necessary, in order to maintain full production, to force velocity and thus increase dirt count. The added slot smoothness more easily passes screened stock without slowing up production. Clogging (which sometimes reduces capacity 50 per cent or more) is practically eliminated.

The conventional design of flat screen plates has remained substantially unchanged for many years. Chromium plating constituted a distinct improvement in screening procedure. With the advent of Crodon and its widespread acceptance by papermakers, the importance of proper screening received increasing recognition. The paper industry has become "screen-plate conscious" from the application of Crodon plate, proved by the consistently successful operation of upwards of 20,000 flat and curved screen plates.

This progress was accelerated through the cooperation of progressive screen plate manufacturers, who improved their own operations to meet the high base metal and finish requirements of Crodon plate. More pronounced smoothness of finished slots became necessary. These and other new developments were readily accepted and have, in a comparatively short time, become recognized as standard practice. Improved screening efficiency—finer slots, cleaner paper, greater capacity, longer life, lower operating costs—these are the more important benefits to the users of screen plates.

The Chromium Corporation of America now offers a new improvement in flat screens designed with open-back construction. The open-back feature is of two-fold advantage: (1) widening of the back slots permits easier stock release and consequently less possibility of clogging; (2) it allows improved coverage of Crodon plate within the slots, where adequate protection is most essential. Although the screen appears to be weakened, this is overcome by the application of Crodon plate, which reinforces and strengthens the plate sufficiently for successful operation under all normal conditions.

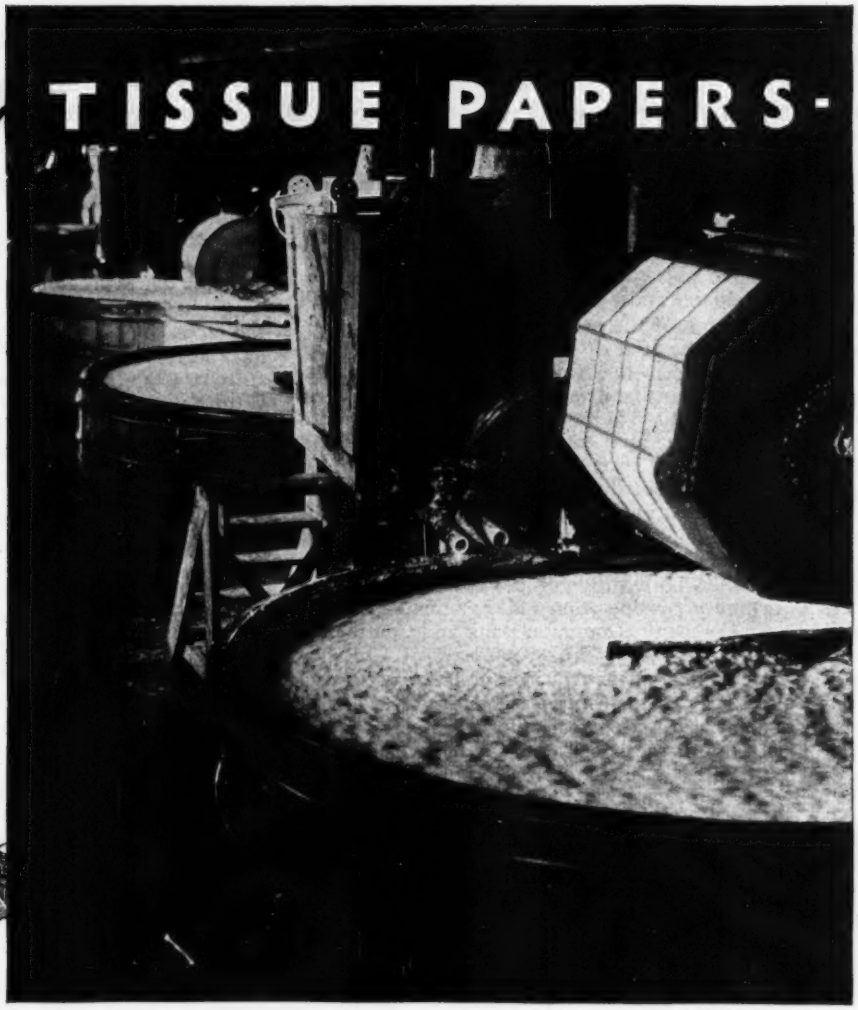
Other outstanding successful applications in the paper industry are on press rolls, suction box covers, slice lips, forming boards, drying drums and embossing rolls. These and other applications are fully described in bulletins which will be furnished upon request to the Chromium Corporation of America, 120 Broadway, New York.

## To Confer With Trade Associations

WASHINGTON, D. C., September 25, 1935—A conference with trade associations will be held in the near future between officials of the United States Tariff Commission and associations interested in the pulp investigation being carried on by the Commission under the Borah resolution passed during the closing hours of Congress.

It is understood that definite plans for the survey will not be determined until after the conference but in the meantime questionnaires are being prepared which will be sent to all mills. Field work has not yet been begun. It is probable that the investigation, when it gets underway will take from four to five months to complete.

*From* TISSUE PAPERS-



BEATER ROOM OF PAPER MILL

*to* FIBRE BOARD CASES ... **THE** parade of paper products from snowy white, crisp tissue wrapping paper to the sturdy fibre board box which transports safely the wants of a nation ... is a long one. Yet, P. Q. Silicate of Soda, that versatile chemical, helps to improve the quality or lower the cost of many in the line.

For decades, reading, writing and wrapping papers have been made with P. Q. Silicate in the beater. A chemical reaction lays the fuzz on the sheet, and gives a smoother surface.

Then, the sheets of paper gripped together by P. Q. Silicate Adhesive form a stiff, strong board. From this comes the modern fibre shipping case. Other paper materials with P. Q. Silicate as the water-resistant, vermin-proof binder produce the new popular wallboard for buildings.

Can you use any of these silicate properties to save time, cut costs or increase production? Our Research Dept. will be glad to be of service or suggest the right silicate and the proper way to use it.

**P.Q. Silicates are used in the Paper Industry for:**

De-inking paper stock
Making spiral tubes
Corrugated paper board
Combined paper board
Sealing shipping containers
Wallboard
Greaseproofing paper
Fibre trunks
Asbestos air cell
Casein solvent for paper coating
Capping paper rolls
Sizing paper
Felt washing

**PHILADELPHIA QUARTZ COMPANY**

*General Offices and Laboratory:* 125 S. Third St., Philadelphia, Pa.
Chicago Sales Office: Engineering Bldg. Eight convenient plants.
Distributors in 60 cities. Sold in Canada by National Silicates Ltd., Toronto.

EST. 1831 PQ REG. U.S. PAT. OFF.

**P.Q. SILICATES OF SODA**

# Further Bids May Be Submitted for Great Lakes

## Final Decision Timed for Adjourned Meeting On October 4—Bondholders Reported to Favor Offer From Group of Fifteen U. S. Newspaper Publishers—Opinion Expressed That Higher Prices Are Needed for Profitable Operations

[FROM OUR REGULAR CORRESPONDENT]

TORONTO, Ont., September 20, 1935—A group of fifteen or more American publishers, all said to be located in the geographical field naturally served by the company, will come into possession of the properties of the Great Lakes Paper Company if the offer of John E. Gefaell and Lyman E. Aldrich, submitted to the National Trust Company, as trustee for the company and favored by the bondholders' committee is accepted. The bondholders met in Toronto today and decided that final consideration of the Gefaell-Aldrich, along with the three others, will be given at an adjourned meeting of bondholders on October 4. Further bids may be submitted in the meantime, however, and the sponsor of at least one offer, R. O. Sweezy, has asked to be permitted to give further details pertaining to newsprint contracts in connection with his proposals. The following tenders were under consideration today: Canadian International Paper Company; Dominion Bank and Continental Illinois National Bank and Trust Company of Chicago; John E. Gefaell and Lynn E. Aldrich, the latter occupying the post of treasurer of the *Chicago Evening News*; R. O. Sweezy Company, Ltd., Montreal. Out of a total of $10,000,000 in first mortgage bonds outstanding over $4,000,000 was represented at the meeting.

On behalf of the Dominion Bank and Continental Illinois, Mr. Rowell explained the view of his clients that the only possibility of profitable operation was on the basis of a larger capacity than 50,000 tons. The preference shares provided in this offer were purely for the purpose of providing additional working capital. The view was taken that the price of paper was too low and must go up.

### B. C. May Lose Japanese Market

Inquiries made indicate that the threatened cutting off of the Japanese market for products of British Columbia Pulp and Paper Company (bleached and easy-bleaching sulphite pulp) has not yet developed. Those close to the company, however, appear to feel that this may take place at any time as a result of the breach between Japan and Canada on trade policies. Fortunately for the company, good progress has been made in the past year or so in broadening its markets so that it would not be so dependent on the one customer as it had been before. The breaking off of trade relations with Japan would affect seriously, however, the sales and earning power of the company for the duration of the dispute, or until such time as the company was engaged in finding other purchasers. The result of operations so far this year has been somewhat below last, but is regarded as satisfactory as a whole. Operating profits for 1934 showed a very marked gain over 1933 and 1932, the total increasing from an operating loss of $76,206 in 1932, to a profit of $404,072 in 1933, and a gain of over $300,000 to the 1934 figures of $706,834. After a depreciation reserve of $395,000 there remained available for interest $295,934 to apply against payments of $317,554.

### Wallpaper Outlook Cheerful

With the introduction of 1936 designs, wallpaper manufacturers have definitely declared war on cheap papers. For the past five years there has been a gradual decrease in the amount of paper bought and the prices paid for it. In this connection the president of one of the larger companies blames the reduction in buying power evidenced through the depression and an effort to maintain volume which hastened the price decline. A third factor has been the increasing volume of plain undistinctive papers which have attracted lower prices on account of their similarity. In a strategic move to recapture public fancy, color will feature the 1936 output. Hundreds of designs from Europe, United States and elsewhere have been checked over in the selection of patterns which, it is hoped, will appeal to Canadian home owners. Generally speaking, wallpaper manufacturers in Canada are optimistic that the coming season holds a "new deal" for the trade in the matter of public acceptance. Spring sales are said to have been the greatest in years, recent increases in apartment house rentals having stimulated demand, tenants becoming more reconciled to the raise when decorating has been promised.

## Patents Granted J. E. Kieffer

J. E. Kieffer, treasurer and general manager of the Kieffer Paper Mills was notified last week that he had been granted another patent on indenting paper. This is the third patent that has been granted him on indenting papers, and he has several other patents pending covering several phases of indented papers. These patents as issued are assigned to the Kieffer Paper Mills.

The Keiffer Paper Mills have several mills under license on a royalty basis manufacturing these cushioning papers. Also the Philip Carey Company, Lockland, Ohio, has taken out a license covering the United States and Canada for the manufacture of insulating material, and is successfully using this process in making insulating asbestos products.

The Kieffer Paper Mills manufacture all of the indenting rolls that are used under Kieffer's process as making these rolls properly takes special designed machinery which is owned by them, all of which enables their licensees to make the paper and insulating material properly and in accordance with the patent.

The consumption of indented papers have been falling off for the last five or six years and its problematical whether this new process ever will bring it back to its former place.

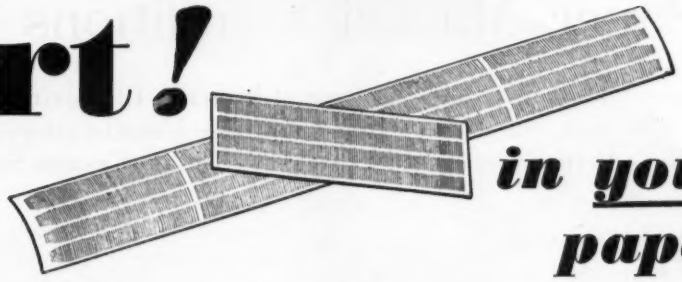
The Kieffer Paper Mills, however, are now single facing their indented product and the sales of this type of paper is helping to make up for the lesser consumption of the unlined indented sheet.

All of their various indented products, both the single faced and unlined, are marketed under the registered trade name of "Shoksorb."

## J. W. Boyle with International Gummed Paper

J. W. Boyle who severed his connection recently with the Miami Valley Coated Paper Company, Franklin, Ohio, and who was previously with the Atlantic Gummed Paper Corporation, Brooklyn, N. Y., and the Brown-Bridge Mills, Troy, Ohio, is now with the International Gummed Paper Corp., Brooklyn, N. Y. Mr. Boyle's experience in gummed and coated paper will be an asset to his new connection.

# Dirt! in your paper?



**Clean paper can be made only with the essential aid of the most efficient screening operations. Too wide slots, forced velocity, partially clogged screens and short useful screen plate life . . . . these are productive of low quality, high cost and dissatisfaction.**

CRODON
*The Chrome Plate*
TRADE MARK REG. U. S. PAT. OFF.

***Let us tell you how to cure these ills with chromium plate . . . . . .***

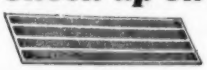
Worn, rough and inaccurate slots result from normal wear of ordinary plates. CRODON provides a permanently hard, durable protection against corrosion. Fine precision of slot dimensions is accurately maintained.

Fine slot sizes are possible with CRODON: not only is cleaner, finer paper obtained, but it is unnecessary, in order to maintain full production, to force velocity and increase dirt count. Scientific co-ordination of slot sizes can be arranged and kept permanent, thus introducing long fibres minus dirt. The added slot smoothness more easily passes screened stock without slowing up production. Clogging (which often reduces capacity 50% or more) is practically eliminated.

CRODON-plated screen plates attain long useful life. The unduly prolonged use of inefficient screens is no concern of mills which have installed chromium-plated plates—they're making cleaner and better paper at lower screening costs than ever before.

The realization of worth-while economies, establishment of new and enviable performance records and trouble-free operation materializes with the aid of CRODON. These attainments have been proved by practical experience of regular paper-making operations. CRODON-plated screens offer outstanding improvements over ordinary plates, whether flat or curved types.

***Check up on your screening operations . . .***



*Let us send you our Bulletin No. 9 to more fully acquaint you with CRODON-plated screen plates.*

Other outstanding successful applications in the paper industry are on press rolls, suction box covers, drying drums and embossing rolls. These and other specific applications are fully described in bulletins which will be furnished upon request.

***The trade-mark CRODON assures the best in chromium plate***

***Most mills appreciate the importance of utilizing a reputable chromium plating service such as CRODON typifies, and which is recognized as a standard specification for the maximum in quality: dependability with resultant cost reductions; and improved operating efficiency.***

NRA

## Chromium Corporation of America

*Executive Offices—120 Broadway, New York*

P. O. Box 1546
Waterbury, Conn.

3125 Perkins Ave.
Cleveland, Ohio

4645 West Chicago Ave.
Chicago, Ill.

# Boston Paper Market Conditions Satisfactory

## Demand for Various Standard Grades of Paper Gradually Improving—Wrapping Paper Business Expands, Although Margin of Profit Continues Unsatisfactory—Demand for Paper Bags Brisk—Paper Stock Section Displays Greater Strength

[FROM OUR REGULAR CORRESPONDENT]

BOSTON, Mass., September 23, 1935—The position of the Boston paper market continued fairly favorable, as a whole, during the last week. Demand for fine paper is slowly improving, with at least a fair volume of sales, although somewhat spotty in some quarters. At one office it was stated that the market was a little slow, but to no marked degree. The general tone of the fine paper division is optimistic.

In wrapping paper, the volume of business was greater than previously, but the margin of profit was very unsatisfactory. Specialties for the holiday season moved well, although the ones used in warm weather naturally fell off in demand. The call for paper bags was very good. Standard kraft is expected to be at 3.87½ for Southern base rolls and 4.00 for Northern base rolls for delivery until October 31.

The paper stock market appeared in a good position, with prospects pointing to a satisfactory volume of business. Old papers were rather active, especially in mixed papers, old newspapers and corrugated boxes. Mixed papers advanced to .27½ @ .30 from .25 @ .30, while old newspapers and corrugated boxes remained firm at the same levels. Bagging continued firm in all grades, as well as new and old domestic rags. No. 2 roofing stock advanced on the high side, with quotations ranging from 1.35 @ 1.40, compared with 1.25 @ 1.30 the previous week. No. 3 roofing stock likewise advanced on the high side, and was quoted at 1.05 @ 1.15, against a former 1.05 @ 1.10. In foreign rags, dark cottons were somewhat slower, but remained at the same price.

### Storrs & Bement Exhibit

The Storrs and Bement Company has opened a new exhibit hall at the offices of the concern, 282 Congress street, where there will be continuous exhibitions, featuring all the various elements which go into Graphic Arts, such as original drawings by foremost artists and designers, exhibits on photography, typography, colors and many others. The exhibitions are said to be the only ones of their kind in New England. Maurice A. Blackmur, sales promotional manager of Storrs and Bement Company, arranges the exhibitions and will have charge of them.

The current one, showing work on papers of the S. D. Warren Company, with mills in Maine and offices in Boston, is exceedingly attractive. Thirty pieces are on the walls, on a black mat, covered by Cellophane, and enclosed in aluminum frames measuring approximately 2x2½ feet. In addition, on a shelf below, is Warren promotional material, including many books, such as those in the "More Business Series" and treatises on direct advertising. This exhibit opened today, September 23, and will be shown until October 5, inclusive. The exhibits, which are specially for printers and advertisers, will be changed from time to time. Announcements will be made through the trade papers, newspapers and by mail.

### T. & H. Calendar Competition

The Tileston and Hollingsworth Company, through Arthur V. Howland, vice president, has sent the following announcement to the trade:

"The T & H 1935 calendar competition was so successful, and we have had so many requests for another, that we are happy to announce the rules for the 1936 competition. The T & H calendar for 1936 will be produced in glorification of New England and the following suggestions are offered: 1. As a vacation. 2. As a center of scenic beauty. 3. As an historic treasure chest. 4. As a center of industrial progress. This calendar will consist of twelve separate sheets, one for each month in the year, and we shall be glad to receive dummies for any of the twelve months. No more than two dummies will be accepted from any one printer, and no dummies will be returned until completion of the calendar reviews—and then only if requested. Dummies must be sized according to specification. There must be no identifying marks on the dummies themselves. We will key them for final identification and they must be in sufficient detail so that they may be judged fairly.

"One, two or three printings may be used, except that, on one of the twelve sheets, four printings may be used. No restricted processes or patented methods of printing will be considered unless they are in general use in the opinion of the judges. The work must be done in the plant of a New England printer; engravings and electrotypes are to be made under the printer's supervision in a New England plant, and any artist, photographer, or layout man employed by him must be practising in New England. Three competent authorities will select the twelve best dummies and the production of the leaves will be awarded according to their decision. One sheet only will be awarded to any printer. All entries for competition are to be sent to Arthur V. Howland, care of Tileston and Hollingsworth Company, 213 Congress street, and must be in his office before October 7, 1935."

### News of the Industry

The first meeting of the season of the New England Paper Merchants Association was held at the Hotel Touraine Thursday evening, with an attendance of about fifty. President William N. Stetson, Jr., presided. Local conditions was the subject of discussion. After the general meeting, the members of the Fine Paper Division and the Wrapping Paper Division gathered for discussion of local problems as affecting their respective divisions.

A general sales meeting of Carter Rice and Company, Corporation, was held Saturday morning for a discussion of sales problems. Frank H. Winter, sales manager, presided.

A three-alarm fire in two storage buildings on Eastern aenue, Chelsea, Mass., occupied by the North Shore Paper Company, of which Benjamin Gold, of Salem, Mass., is president, caused damage estimated at $100,000, Tuesday. The buildings, at the United States Rubber Company plant, and part of the property formerly owned by the Revere Rubber Company, were full of bales of waste paper.

# *Any paper machine operating* THEN *is a waster of profits today*

PAPER machinery engineers agree that 15 years is as long as Fourdriniers and other paper machines can operate most *profitably* without rehabilitation.

Yet 8 out of every 10 machines now operating have been in service since the War.

Not only do such machines add excessively to your present operating costs, but they are also fast approaching the time when a long series of repairs will become necessary.

It is cheaper for you to modernize your machines today—top to bottom—than it will be to pay miscellaneous repair bills during the years to come.

An S & W engineer will, without charge, look over your equipment and suggest the improvements considered necessary for economical operation. Then S & W, builders of the three widest Fourdriniers operating today on the finest tissue and condenser papers, will work with you and your consulting engineer to bring those machines up to 1935 standards.

A letter to S & W will schedule a Modernization Engineer to call.

*The* CONSULTING ENGINEER *has a Part in the Picture*

S & W *will gladly work with you and your consulting engineer in designing and building straight, Edward & Harper type Fourdriniers; cylinder machines; wet machines; bindersboard machines and leather board machines.*

"CARRYING THE TORCH"

S & W's *part in the country's paper-making history and its facilities for contributing to the paper-making present. Write for this valuable booklet.*

★

# *The* SMITH & WINCHESTER *Manufacturing Company*

PLANT AND OFFICES AT SOUTH WINDHAM, CONNECTICUT

1115

# Northwest Paper Mill Superintendents to Meet

## Fall Convention Scheduled for Green Bay, Wis., Friday and Saturday, September 27 and 28—Sessions to Be Devoted to Addresses of Technical Interest and Discussions of Problems—Royal Reception for Visitors Being Arranged

[FROM OUR REGULAR CORRESPONDENT]

APPLETON, Wis., September 23, 1935—With the arrival of the fall season, organizations within the paper industry are resuming their meetings. One of the largest scheduled this month is the fall convention of the Northwest Division of the American Paper and Pulp Mill Superintendents Association. It is to take place Friday and Saturday, September 27 and 28 at Green Bay, Wis. An attendance of approximately 400 is anticipated. Sessions will be devoted to addresses of technical interest, and round table discussions on problems. Mills at Green Bay are planning a royal reception for the visitors. Tours of inspection are being arranged, there will be stag luncheon, a golf tournament at the Oneida Golf and Riding Club, and a banquet at Hotel Northland. Special entertainment events also are being planned for the women guests.

### K. C. Chemical Engineers Meet

Chemical engineers of Kimberly-Clark Corporation resumed their meetings last week with a dinner and short business meeting at Conway Hotel, Appleton, Wis., and a lecture hour at the Institute of Paper Chemistry. Dr. M. N. Daivs, Dr. Walter Roehr and H. E. Malmstrom, of the company's physics department, talked on "New Paper Testing Equipment." Twenty-five were present. Plans are under consideration for the entire group to visit the United States Forest Products Laboratory at Madison, Wis., in the near future, where new processes are constantly being developed for the paper industry.

### Charles W. Boyer To Lecture

The annual meeting of the members of the Institute of Paper Chemistry will be held at the Institute at 10 o'clock Saturday morning, September 27. Reports of operations will be submitted, and policies mapped out for the coming year. Dr. Henry M. Wriston, director of the Institute, will preside. Representatives of member mills from all parts of the country are expected to be present.

Charles W. Boyce, executive secretary of the American Pulp and Paper Association, will be at the Institute September 25, 26 and 27 for a series of lectures to the student body and staff. He will sketch the history of paper making, will explain the importance of the paper industry in the United States to the world total, will present the current economic status of democratic industry, and will conduct a discussion of economic factors that currently face the industry. This is the first time an expert of the standing and experience of Mr. Boyce has been called in by the Institute, and other such speakers are to be invited from time to time in the future.

### Stimulating Safety Efforts

As a means of stimulating safety efforts, emplopees of the Kimberly-Clark Corporation mill at Kimberly, Wis., have hoisted a safety flag on a 20-foot iron pole erected for the purpose. The flag is blue, with the word "Safety" in large gold letters. The flag will fly day and night until an accident causes it to be lowered. The employees are making every effort to maintain a perfect safety record, especially because of the company's offer to pay the expenses of delegates to the National Safety Congress at Louisville, Ky. in October. Several other Kimberly-Clark mills also have clear records, and a tie looms when the contest ends October 6. In case of a tie, the winners will be picked on the basis of the safety record for the last two years.

### Pulp and Paper Unions Convene

Another recent gathering was that of the district council of the pulp and paper unions for Wisconsin and Upper Michigan on Sunday, September 15, at Manistique, Mich. Sessions were held at Arrowhead Inn. Among the speakers were the Hon. George J. Schneider, member of congress from Appleton, Wis.; Ray Richards, of Wisconsin Rapids, Wis., vice-president of the International Brotherhood of Pulp, Sulphite and Paper Mill Workers; E. Lambton, general representative of the Brotherhood, and John Luecke of Escanaba, Mich., state senator of Michigan.

### News of the Industry

An addition 89 by 90 feet under construction at the Hewitt Machine Shop, Neenah, Wis., will be completed within another month. The work is being done by C. R. Meyer Sons & Company, of Oshkosh, Wis., and will cost about $15,000. Operations in the making of paper mill equipment will be expanded when the building is ready for occupancy.

Speaking at a Kiwanis Club luncheon at Marinette, Wis., John V. Ziemann, paper mill superintendent, of that city, expressed his belief that northern paper mills making certain grades are doomed because of the increasing competition by southern mills. He based his opinion on the raw material situation, since timber can be grown much more rapidly in the south, and labor is much cheaper. He explained the entire process of paper making.

A tract of forty acres in Marinette County, Wisconsin, has been taken over by the Stephenson Conservation Club as a tree nursery. Several thousand Norway and white pine trees have been set out, and other plantings will follow. The seedlings were obtained from the Wisconsin Conservation Commission. Work on the project is being done by members of a CCC camp nearby.

Announcement has been made of the marriage August 28 in San Francisco, Cal., of Dr. Otto Kress, technical director of the Institute of Paper Chemistry, Appleton, Wis., and Miss Florence M. Thompson of San Farncisco. Dr. Kress spent the summer in China, and returned to his duties, bringing his bride with him. They will reside at the Doty apartments at Neenah, Wis.

## I. P. Co. Announces Appointments

The International Paper Company announces that Alexander H. Campbell has been elected vice-president in charge of traffic and transportation. Hugo Ignatius has been appointed general traffic manager with headquarters in New York. C. C. Barnes has been appointed manager of transportation with headquarters also in New York, and C. E. Jones has been appointed Southern traffic manager of the company and traffic manager of Southern Kraft Corporation with headquarters in Mobile, Ala. F. H. Rippetoe has been appointed assistant manager of transportation with headquarters in Atlanta, Ga.

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# PRINTING QUALITIES
## *for all your* WAXING *stocks*

A primary requirement of modern waxing stocks is good printing qualities. Stocks of this type must retain their opacity in contact with oils and fats. They must be sufficiently opaque to make printed matter stand out boldly.

From 3 to 5% of Titanox-A (Titanium Dioxide) gives your waxing sheets a degree of opacity and brightness that no other pigment can approach, regardless of the quantity used.

Titanox-A has the highest index of refraction of all the white pigments. In addition to opacifying waxing paper, it is widely used in stocks of every type — bond, envelope, writing, magazine, book, tissue lined board or tub sized papers.

Specifically Titanox-A offers these impressive advantages: (1) fine particle size; (2) exceptional brightness; (3) high index of refraction; (4) chemical inertness; (5) easy dispersion. Furthermore it is easily held in suspension; has high retention even in lightweight stocks; and maintains the strength of the paper because of the small quantity needed to produce desired results.

The services of our paper technologists are always available. Just address our nearest branch office.

**TITANIUM PIGMENT CO., INC.**

*Manufacturers of*
TITANOX-A *(Titanium Dioxide)*
TITANOX-B *(Titanium Barium Pigment)*
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111 Broadway, New York, N. Y.; Carondelet Station, St. Louis, Mo.; National Lead Company (Pacific Coast Branch), 2240 24th St., San Francisco, Calif., Canadian Distributor: Wilson Paterson, Gifford, Ltd., 3552 St. Patrick St., Montreal; 132 St. Helen's Avenue, Toronto.

TITANOX

# TITANOX

# Demand for Paper Fairly Active In Chicago

## Paper Mill Representatives Report Most Grades of Paper Moving Freely—Slightly Better Request Experienced for Fine Papers—Kraft Wrapping Paper Business Unusually Good—Paper Board Division Exhibits Steadiness

[FROM OUR REGULAR CORRESPONDENT]

CHICAGO, Ill., September 23, 1935—The Chicago paper market has been undergoing some minor price adjustments that are expected to eventually actually strengthen certain grades. These readjustments, according to local paper executives, were overdue and will help to actually stabilize the market. Most of the grades reported a continuation of fair business during the week. Kraft business was said to be unusually good both from the standpoint of volume and stabilized price. Groundwoods also forged ahead with a widening demand. Books and covers showed comparatively little change. Fine papers, in general, and even with the minor adjustments accounted for, found no concern over the price structure and some satisfaction over slightly increased demand. Paperboard conditions were reported as "steady." Waste papers were slightly more active, particularly in the higher grades.

### Association Activities

Members of the National Paperboard Association have been urged to do everything within their power to promote the use of individual paperboard cartons in connection with the packaging of alcoholic beverages, a task admittedly difficult because of the attitude of several of the regulatory State Commissions who have refused to accept shipments of liquor when the bottles are individually packaged. On the other hand, the further development of the folding carton in the liquor industry will mean further business for the paperboard industry. A mailing recently sent out from the Chicago offices of the Association contains an appeal for cooperation along with an analysis of the Federal Alcohol Control Bill.

The communication also pointed out that bulk sales of liquor would reduce the consumption of paperboard, thus seriously affecting employment in localities where mills are located, with probably 100,000 employees vitally interested. Further "ammunition" to bring to the attention of legislators and users pointed out that "members of the industry purchase direct from farmers thousands of tons of straw, an otherwise waste product which, if present provisions are changed to reduce the use of paperboard packages for liquor, will further harm the farm market." The Association also points out that bulk sales will promote bootlegging and that communities should do everything within their power to retain the provisions now favorable to the industry.

The Chicago contingent of the National Paper Trade Association is unanimous in the belief that the forthcoming fall meeting of the National Paper Trade Association is going to be one of the most momentous in the history of the association. Scheduled for the Hotel Stevens from September 23 to 26, the meetings seem likely to draw together one of the largest group meetings yet held. Included in the problems to be discussed are the ones centering around the June report of the executive committee in relation the N. P. T. A. program of work involving trade practice rules for possible submission to the Fair Trade Commission; elimination of discriminatory prices; the practice of direct selling to the merchants legitimate trade; possible control of job lot and seconds business and an imposing list of other recommendations all based on the keynote of the 1935 meeting which is reported as being "Protection of the Merchants' Interests."

While the regular program will occupy most of the time of the Association and closely related problems will get the first call, there are two or three outstanding feature events including the annual tournament sponsored by the Chicago division of the Salesmen's Association of the Paper Industry and the appearance of Bennett Chapple, American Rolling Mills, at a general session on the morning of September 24. Mr. Chapple, noted public relations executive, will probably have something very unusual for the paper trade executives.

The Western Paper Association met at the Union League Club on September 13 with H. R. Washburn calling the session reported to discuss plans for the Fall program. The Chicago Paper Association, active group of local coarse paper merchants, is also ready to help in every way. At the Monday meeting of the Salesmen's Association, William Bond Wheelwright extended an invitation to the salesmen to view his personal collection of prints, advertising and paper uses which will be installed in the Stevens Hotel on the 23rd.

### News of the Industry

Bermingham & Prosser, Chicago jobbing firm, has recently announced an extension of its sales program based on the addition of a complete line of bonds and ledgers and envelopes. This addition, when coupled with the already favorably known line of book papers which the firm has long featured, will give Bermingham & Prosser a complete assortment of printing papers to be distributed intensively through the addition of new salesmen and an augmenting of the advertising and general merchandising program.

The Chicago market is quite interested in the news that insulated containers designed to hold frozen goods are soon to be introduced on the market. The container is made by multiple ply walls of paper or cardboard and an intermediate layer of felt provided with plenty of air holes. Other insulating materials may also be used in the central wall. The box is so constructed that if desired dry ice can be used to fill in the central section of the two walls. It is understood that the container has been patented by Samuel Ginsberg, of Jamaica Plain, Mass.

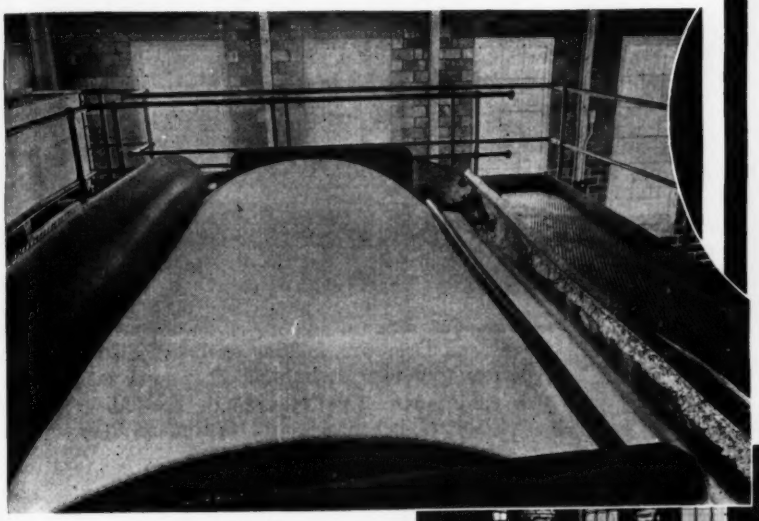
Merle Sears, president of the Merle Sears Paper Box Company, of Danville, Ill., has been nominated for re-election as a director of the Illinois Chamber of Commerce. If elected, it will be the third year that the well known paper board executive has served the State Chamber. Another member of the industry, Ray Wantz, of the Rockford Fibre Container Company, is just completing his first term as president of the Illinois Manufacturers Association.

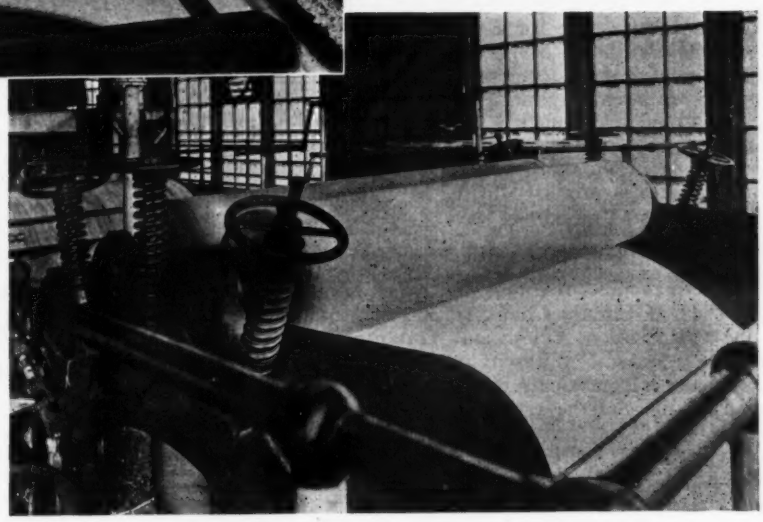
The Seibert Paper Company, 205 West Wacker Drive, Chicago, has recently announced the addition of the complete line of the Groveton Paper Company of Groveton, New York. The line includes sulphite bonds, ledgers, index bristols, offset papers, envelope manilas and other similar papers and will be sold throughout the midwest territory by the Seibert organization in addition to the products of the Minnesota and Ontario Paper Company.

# FOR THICKENING and WASHING

## *more and more mills are turning to*

IMPCO MACHINES





**"IMPCO"**

**Vacuum Washer and High Density Thickener Operating on Sulphite and Soda in Prominent New York State Mill.**

**"Impco" Centrifugal Screens, "Impco" Flat Screens (Dunbar Drive), Vacuum Filters, Pneumatic Savealls, Pneumatic Washers, Pneumatic Thickeners, Knotters, Deckers, Cylinder Machines, Wet Machines.**

***Upon request our representatives are available to make tests and assist mills in planning installations.***

**IMPROVED PAPER MACHINERY CORPORATION**

**Nashua, New Hampshire**

# Paper Demand Continues Active In Philadelphia

## Upward Trend Experienced In Various Divisions of Paper Industry Still Maintains—Outlook for Closing Months of Year Encouraging—Representative Group of Paper and Twine Merchants Attend Fall Meeting At Adelphia Hotel

[FROM OUR REGULAR CORRESPONDENT]

PHILADELPHIA, Pa., September 23, 1935—The upward trend of business which the paper industry has experienced thus far this month of September still maintains, and now with Fall approaching and with business less apprehensive over what is to come, it looks as though the paper industry had gotten off to a good start—keeping in mind, of course, the volatile factor of the political situation in this city this coming November.

### Association Activities

The first Fall meeting of the Philadelphia Paper and Cordage Association was held at the Adelphia Hotel on Friday, September 20. The meeting was attended by a representative group from the paper and twine houses in the Philadelphia area.

The speaker and guest of honor was Howard Ehmke, star pitcher of Connie Mack's Championship Athletics of 1928 and 1929, and hero of the 1929 opening World Series game. Mr. Ehmke outlined the highlights of his career and gave a dramatic account of the events leading up to that memorable victory over the Chicago Cubs six years ago, in which he climaxed his career by dramatically striking out thirteen men for a new World Series record.

At the conclusion of his talk Mr. Ehmke autographed a baseball for the association. Lots were drawn for possession of the trophy, and Martin Mutz, of the Wheeler Paper Company, somehow came up with the ball. The next meeting of the association will be held on Friday, October 18, when another interesting program of business and pleasure is promised by E. K. Lay, chairman of the Entertainment Committee.

### New Corrugated Paper Display

Something new in corrugated paper is being shown by the T. H. B. Smythe Company, 30 South 6th street. It is known as Flexton, Velton and Traton and is available in a rainbow splash of different hues; its flexibility and sturdiness make it increasingly valuable for window display. On entering the Smythe establishment, your attention is arrested by "Flexy," which has all the earmarks of a masquerader of the approaching Hallowe'en. Mr. Smythe explained that "He is made of a corrugated product which is distinctively a 1935 development and which is especially designed for window display decoration. The wide variety of colors in which this paper and kindred items are now made make it particularly valuable for the holiday seasons for decorations during Hallowe'en, Thanksgiving and Christmas."

"Flexy" is made 100 per cent of Flexton, trade name of this new product distributed in this area by the Smythe Company. This corrugated paper, which is made to bend easily into unusual shapes, is offered in seventeen different colors.

In the same paper line are Traton, similar to Flexton, but heavier; Flexton, Jr., similar but lighter weight than Flexton, and Velton, a heavy crinkled bond paper also adapted for displays in showcases, windows, covering floors, etc. These are all manufactured by the Hinde and Dauch Paper Company, of Sandusky, Ohio.

Velton also appears in seventeen different colors: while Flexton, Jr., is making its bow in twenty assorted colors.

"The value of a good corrugated paper for window display," said Mr. Smythe, lies primarily in its cost and in the ease of manipulation. Corrugated paper costs only about 25 per cent as much as wallboard or wood for display purposes, a very important difference for the merchant. Flexton and its kindred items are sturdy. Made into display pillars, with flat tops upon which articles may be placed, Flexton is strong enough to bear a weight of many pounds.

"And, of course, it is easy to manipulate. Try to do with wood what we have done with corrugated in making 'Flexy' and you create for yourself a job that is a job. Even his buttons are cut from corrugated and his necktie and pocket handkerchief are of heavy crepe paper."

The J. L. N. Smythe Company is one of the older paper firms of this city. It was founded in 1900 by J. L. N. Smythe, and sells throughout Eastern Pennsylvania, South Jersey and Delaware, holding exclusive distribution in the sector on a number of lines.

In addition to T. H. B. Smythe, president and son of the founder, the officers are H. Elmore Platt and W. C. Melcher, Jr., vice-presidents.

### News of the Industry

Samuel S. Shyrock, secretary and treasurer of Shyrock Bros., 924 Cherry street, has just returned from an interesting airplane trip of the west coast, visiting Los Angeles, San Diego Fair, Mexico, then back to Los Angeles and San Francisco.

T. H. B. Smythe, president of the J. L. N. Smythe Company, left on Sunday to attend the National Paper Trade Association Convention being held this week in Chicago. Mr. Smythe is expected to return the first part of the coming week.

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## New Celotex Plan Approved by Court

Judge John P. Nields, in the United States District Court, at Wilmington, Del., last week, approved a modified reorganization plan of the Celotex Company, providing for $500,000 in new working capital obtained by Bror Dahlberg, president, from Wallace Grove of New York.

The company, which manufactures insulating board, is incorporated in Delaware and has been administered by the District Court in equity receivership and bankruptcy for the last three years.

Judge Nield's opinion approving the reorganization brought out that Mr. Groves was the only person Mr. Dahlberg could find who would furnish the new working capital under acceptable terms. The funds will enable the company to go ahead with manufacturing operations.

Under the reorganization, holders of two shares of preferred stock will be entitled to one share of new preferred, one share of new common and the right to subscribe to an extra share of common at $6.66 a share.

The exchange plan has been approved by 68.9 per cent of the preferred stockholders. The plan also provides for an 83 per cent reduction in fixed charges, from $306,722.50, three years ago, to $53,397.50.

A POIRIER INSTALLATION MULTI-CYLINDER BOARD MACHINE

## MAINTAIN BASIS WEIGHTS BY INSTALLING THESE GOVERNORS

Many mills are now 100% equipped.
*They bought one on trial—proved its advantages and sent in repeat orders.*

# Poirier Weight Governor

is a most efficient device for controlling volume at the stuff-box.

It automatically controls weight of pulp at any predetermined amount, operating equally well on both light or heavy stock, on changed filler content or freeness. It corrects faulty chest agitation.

It is built in several sizes for all tonnage demands.

TO BOARD PLANTS
We invite inspection of our latest installations controlling caliper and weight of both filler and liner stock.

*Send for information to sales representative*
**PAPER AND INDUSTRIAL APPLIANCES, INC.**
122 E. 42nd Street New York, N. Y.

**STURTEVANT MILL CO.** HARRISON SQUARE **BOSTON, MASS.**
SOLE MANUFACTURERS

## Government Paper Bids and Awards

[FROM OUR REGULAR CORRESPONDENT]

WASHINGTON, D. C., September 25, 1935—The Government Printing Office has received bids for 196,680 pounds (440,000 sheets) of white sulphite index paper. All of the bids received were at 6.06 cents per pound except two. At 6.06 cents were the following; Virginia Paper Company, Whitaker Paper Company, R. P. Andrews Paper Company, George W. Millar & Co., Reese & Reese, Inc., Barton, Duer & Koch Paper Company, and Mathers-Lamm Paper Company. Other bids; Paper Corporation of the United States, 5.93 cents; and J. W. Butler Paper Company, 5.9 cents.

Bids were also received for 10,000 pounds (62,500 sheets) of white blotting paper. All were at 9.21 cents per pound as follows: R. P. Andrews Paper Company, Whitaker Paper Company, Virginia Paper Company, Barton, Duer & Koch Paper Company, and Mathers-Lamm Paper Company.

The Printing Office also received bids for 18,720 pounds (120,000 sheets) of white ledger paper. All bids were at 6.54 cents per pound as follows: Champion Coated Paper Company, Whitaker Paper Company, Bulkley, Dunton & Co., Reese & Reese, Inc., Graham Paper Company, Aetna Paper Company, Barton, Duer & Koch Paper Company, R. P. Andrews Paper Company, J. W. Butler Paper Company, Dobler & Mudge Paper Company, Paper Corporation of the United States; and Mathers-Lamm Paper Company.

For 3,000 pounds of No. 2 kraft wrapping paper: Reese & Reese, Inc., at 4.04 cents per pound; Whitaker Paper Company, 4.125 cents less 2 per cent; and Mathers-Lamm Paper Company, 4.125 cents.

For 5,000 sheets of red railroad board; at $27.94 per M; Whitaker Paper Company, Dobler & Mudge; Walker-Goulard-Plehn Company; and Virginia Paper Company; George W. Millar & Co., $30.00; Mathers-Lamm Paper Company, $28.50; and Bulkley, Dunton & Co., $28.80.

The following bids were received at 6.06 cents per pound for 36,400 pounds (200,000 sheets) of white sulphite index paper; Virginia Paper Company, Whitaker Paper Company, Mathers-Lamm Paper Company, George W. Millar & Co., Old Dominion Paper Company, Reese & Reese, Inc., Aetna Paper Company, Barton, Duer & Koch Paper Company, and R. P. Andrews Paper Company. Bids were received at 5.9 cents from J. W. Butler Paper Company, and Paper Corporation of the United States.

The Government Printing Office has announced the following paper awards:

The R. P. Andrews Paper Company will furnish 1,995 pounds (14,000 sheets) of 100 per cent rag, salmon and blue rag ledger paper at 24.3185 cents per pound, bids for which were received on September 13.

Reese & Reese, Inc., will furnish 3,000 pounds (50,000 sheets) of 24 x 36, No. 2 kraft wrapping paper at 4.04 cents per pound, bids for which were received on September 11.

The R. P. Andrews Paper Company will furnish 10,000 pounds (62,000 sheets) of 25 per cent rag, 19 x 24 white blotting paper at 9.21 cents per pound. The J. W. Butler Paper Company will furnish 196,680 pounds (440,000 sheets) of 32½ x 48½ single ply white sulphite index paper at 5.9 cents per pound and the R. P. Andrews Paper Company will also furnish 16,300 pounds (100,000 sheets) of white sulphite ledger paper at 6.54 cents per pound. Bids for all of these items were received on September 9.

The Old Dominion Paper Company will furnish 3,069 pounds (15,900 sheets) of 28 x 41 white lithograph finish paper at 6.52 cents per pound and the Whitaker Paper Company will furnish 5,000 sheets of 22 x 28, 4 ply red railroad board at $27.94 per M sheets. Bids for these items were received on September 6.

John F. Post will furnish 396 pounds (2,000 sheets) of 28 x 42, 198 golden rod coated book paper at 15.75 cents per pound, bids for which were received on September 4.

The Whitaker Paper Company will furnish 46,000 sheets of 20 x 24 buff gummed paper at $7.22 per M sheets and the Paper Corporation of the United States will furnish 17,900 pounds (100,000 sheets) of 33 x 43 white antique book paper at 5.25 cents per pound. Bids for these items were received on August 21.

## Union Bag & Paper Co. Gets Decision

[FROM OUR REGULAR CORRESPONDENT]

HUDSON FALLS, N. Y., September 23, 1935—In a decision this week Supreme Court Justice Lawrence denied the application of Amasa Howland, Richard J. Howland and Mary T. Heidorf for an injunction to restrain the Union Bag and Paper Company and the Union Bag and Paper Power Corporation from maintenance of the Bakers Falls dam in this village. The case was tried before Judge Lawrence early in the summer. At that time the plaintiffs claimed flood damages to property and sought $50,000 damages and an injunction to restrain the defendants from using the dam and flashboards. Following the trial the complaint against the paper company was dismissed but the case against the Union Bag and Paper Power Corporation was continued.

Justice Lawrence ruled that the plaintiffs could only be entitled to nominal damages for the flooding which they claimed had occurred and that while a technical right of the plaintiffs had been invaded they should be denied an injunction until such time as they could show that damages had been sustained. In making his decision Judge Lawrence, after reviewing the history of the ownership of the properties involved, found that the plaintiffs own a portion of the river bed but that the Delaware and Hudson Railroad is entitled to sole possession of the bank of the river within the area of its right of way.

## Schroon River To Start Paper Machine

WARRENSBURG, N. Y., September 23, 1935—Plans are under way for starting the paper machine at the Schroon River Pulp and Paper Company within the next week and schedules are to be resumed on the basis of three shifts daily. Since its reorganization last fall operations were conducted with day and night shifts until the mill closed in July to make needed repairs. An official announced that the new beaters have been placed in position while other improvements have also been made in the beater department. The task of overhauling the other equipment in the plant has also been completed. Grinders have been running all summer under full speed taking advantage of high water and a large stock of pulp is now in reserve waiting for the start of operations. It was also stated that more orders are on hand than when the plant reopened last fall. Franklin E. Pasco will continue as superintendent.

## Boner Envelope Co. Builds

[FROM OUR REGULAR CORRESPONDENT]

INDIANAPOLIS, IND., September 23, 1935—The Boner Envelope Company here is constructing a new addition to be used for storage envelope facilities.

# THORSEN BEATER

## DOWNINGTOWN-BUILT

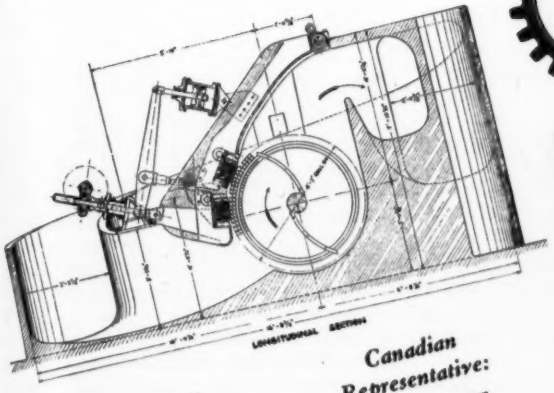
Effects Large Power Savings . . . up to 700 percent less h.p. consumed in comparison with conventional beaters. Circulating load 12%.

Permits obtaining "slow beating" effects at certain densities, and in quicker time, due to its "floating" bedplate adjustable with air pressure.

Duplicates work of three conventional beaters through entirely new design and method of beating. Roll turns in opposite direction as compared with conventional beater. A thin film sufficient to cover only ends of bars is lifted up through bedplate area and thereafter projected to high part of return slope from which point the drop back and around midfeather to beater roll is entirely due to gravity.

Now in successful operation on kraft, sulphite, rag, and all other kinds of stock.

Thirty-two Thorsens in operation in one mill alone. Investigate this new modern method of beating. Full particulars mailed on request.



*Typical Installation of Thorsen Beaters*

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Paper and Industrial Appliances, Ltd.

**PAPER AND INDUSTRIAL APPLIANCES, INC.**
**122 EAST FORTY-SECOND STREET**
**NEW YORK CITY**

# CONSTRUCTION NEWS

*A Summary of Vital Facts Regarding Construction, Finances and Operation of Paper Mills*

**Construction News**

**Cleveland, Ohio**—The River Raisin Paper Company, Monroe, Mich., manufacturer of box board, fiber board and kindred paper stocks, has awarded general contract to the A. M. Higley Company, 2036 East 22nd street, Cleveland, for alterations and improvements in section of former local works of Peerless Motor Car Company, Woodland avenue, S. E., and East 93rd street, Cleveland, recently secured under lease for new local plant, previously reported in these columns. Work will be placed under way at once and building made available for equipment and operating facilities. New plant will approximate 40,000 square feet of floor space, and will be used for production of corrugated board and paper containers, cartons, cases, etc., with portion given over for storage and distribution of products manufactured at the Monroe mill. New plant will represent an investment of about $150,000. James Hamilton will be local manager.

**New Brunswick, N. J.**—The United States Playing Card Company, Park avenue, Cincinnati, Ohio, has completed plans for new Eastern converting and manufacturing plant on New Jersey avenue, New Brunswick, designed for large capacity. It will be one-story, 155 x 350 feet, reported to cost over $200,000, including equipment. Bids are being asked on general contract and superstructure is scheduled to begin at early date. Lockwood, Greene Engineers, Inc., 30 Rockefeller Plaza, New York, N. Y., is architect and engineer.

**New York, N. Y.**—Olitsky & Miller, Inc., recently chartered with capital of $10,000, to manufacture paper boxes, cartons and other containers, is said to be arranging early operation of local plant. Edward Hoffman, 291 Broadway, New York, is one of the incorporators and representative for company.

**Tulsa, Okla.**—Tulsa Paper Company, Tulsa, paper stocks for commercial and other service, has arranged for lease of space in local building at Cincinnati avenue and Archer street, totaling about 12,000 square feet of floor area, and will occupy for new plant unit, including storage and distributing facilities.

**Los Angeles, Cal.**—The Zellerbach Paper Company, 3000 East 12th street, has begun superstructure for new one-story plant unit at 1200 South Evergreen street, lately noted in these columns, and is awarding miscellaneous contracts for different features of construction, including reinforcing steel to Truscon Steel Company; miscellaneous iron work to Pennsylvania Iron and Steel Company; sheet metal work to Fred Dee Sheet Metal Works; and plumbing to W. D. Melville, all of Los Angeles. New plant will be 182 x 940 feet, designed for paper converting, storage and distributing, and will represent an investment of close to $225,000, including equipment. The Austin Company of California, 777 East Washington street, Los Angeles, is general contractor. Ralph Beebe, 1976 San Pablo avenue, Berkeley, Cal., and Leland S. Rosener, 233 Sansome street, San Francisco, Cal., are engineers.

**Rumford, Me.**—The Continental Paper and Bag Corporation, 220 East 42nd street, New York, N. Y., is curtailing operations at mill at Rumford, and will transfer all large bag orders to mills in the South. A total of four paper bag machines and accessories have been removed from the plant, two of these units being transferred to an affiliated mill at Mobile, Ala., and the other two dismantled permanently. This reduces the local plant equipment to four machines and it is understood that the capacity will be maintained on this basis in the future. Company is said to be arranged to raze a portion of the plant to reduce assessment. The change is being brought about through lower production in the South, representing a saving up to $20.00 a ton in bag manufacture there.

**Corning, N. Y.**—The Corning Fibre Box Corporation, Hammel street, manufacturer of corrugated fibre boxes and containers, is awarding miscellaneous contracts for new one-story plant addition, to be used primarily for storage and distribution, for general award recently was made to the J. Cunningham Company, 101 South avenue, Elmira, N. Y. Structural steel is being furnished by the McClintic-Marshall Corporation, Buffalo, N. Y. New unit will be pushed to early completion. It is reported to cost in excess of $25,000, including equipment.

**Houston, Tex.**—Clarke & Courts, Inc., Galveston, Tex., wholesale paper products, etc., has plans under way for construction of new branch plant on West Clay street, near Van Buren street, Houston, to be one-story, 180 x 220 feet, with three-story tower in center. A portion of the new unit will be used for converting division, and the remainrer for storage and distribution. It is estimated to cost over $75,000, including equipment. Joseph Finger, Inc., National Standard Bank Building, Houston, is architect.

**Holyoke, Mass.**—The American Writing Paper Company has plans maturing for reorganization of company, in progress for a number of months, under the new Federal bankruptcy law, and hearing is scheduled at Federal Court, Boston, November 4. The company has consolidated mill properties in past months, preparatory to reorganization program.

**Washington, D. C.**—The Columbia Specialty Paper Box Company, 228 First street, N. W., manufacturer of paper boxes and containers, has work in progress on new four-story addition to plant, previously referred to in these columns, and proposes to have structure ready for equipment installation at early date. It is reported to cost in excess of $60,000, with machinery. C. F. Gardner, Washington, is general contractor. A. J. Scullen, 1224 Lawrence street, N. E., Washington, is architect and engineer.

**Rensselaer, N. Y.**—F. C. Huyck & Sons, Albany, N.

Y., manufacturer of papermakers' felts and allied products, has awarded general contract to J. McKinney & Son, 925 Broadway, Albany, for construction of two new one-story buildings in the Rensselaer district, to be used primarily for storage and distributing service. Work will be placed under way at once. Cost estimated close to $45,000, with equipment.

**New Companies**

**Brooklyn, N. Y.**—The Jaffe Sales Corporation has been organized with capital of $20,000, to deal in paper products. New company is represented by Samuel Finkelstein, 29 Broadway, New York, N. Y.

**New York, N. Y.**—The Lehman Paper Corporation has been formed with capital of 200 shares of stock, no par value, to deal in paper goods of various kinds. New company is represented by Morris Mond, 1440 Broadway, New York, attorney.

**Saddle River, N. J.**—The North Jersey Paper Company, Inc., has been incorporated with capital of $125,000, to manufacture and deal in paper products. John C. Ware, Jr., Saddle River, is principal incorporator and representative.

**New York, N. Y.**—The Aetna Egg Case Supply Company, Inc., has been chartered with capital of $2,000, to manufacture and deal in corrugated board egg cases and allied paperboard products. The incorporators include Leo Trattner, 50 East 18th street, Brooklyn; and William R. Magrill, 110 West 40th street, New York, N. Y.

## Bates Multi-Wall Bag Men Meet

The Seventh Annual International Convention of the manufacturers of Bates Multi-Wall Paper Bags opened Tuesday at the Waldorf-Astoria, New York. Fifty delegates, representing fifteen countries, were present.

Among those attending the convention are leading kraft paper manufacturers from Sweden, Norway, Finland, Germany, France and Mexico, who have found in the multi-wall paper bag an important outlet for the increased consumption of kraft paper. In the group also are leading European cement manufacturers and flour millers.

The session opened with a meeting in the Waldorf-Astoria on Tuesday, September 17, at which motion pictures of the automatic filling of multi-wall paper valve bags were shown. On Wednesday the party went in chartered buses to the Lehigh Valley to inspect cement plants. The delegates were the guests of the Alpha Portland Cement Co. and of the Lehigh Portland Cement Co., and were entertained at a luncheon at the Hotel Easton. In the afternoon they visited the Nazareth, Pa., plant of the Bates Valve Bag Corporation.

On Friday the delegates were taken to the Edgewater, N. J., and Long Island City refineries of the National Sugar Refining Co., to witness the packing of sugar in multi-wall paper bags. They were entertained at a luncheon in the Hotel Bossert.

On Saturday a banquet in honor of the delegates was given at the Waldorf-Astoria Hotel.

Sunday night the delegates left in special cars for Three Rivers, Que., where they were guests of Consolidated Paper Corporation Limited. They were entertained that night at Grand'Mere. Tuesday they were guests of the Canada Cement Company Limited in Montreal, and Wednesday in Toronto, they inspected flour mills and bakeries where multi-wall paper bags are used. There they were guests also of the Maple Leaf Milling Company, Ltd., and Copeland Flour Mills Ltd. Thursday the party will be in Detroit, where they will inspect the River Rouge plant of the Ford Motor Company, being entertained there at luncheon, and in the afternoon will visit the chemical plant of Michigan Alkali Company, where they will see soda ash, bicarbonate of soda and calcium chloride packed in multi-wall bags. The party will be entertained in the evening by the Michigan Alkali Company.

After a stop at Niagara Falls early Friday morning, the delegates will visit the fertilizer plant of the Cooperative G. L. F. Company, Inc., at Batavia, N. Y., going on from there to Oswego to inspect the multi-wall paper bag factory of Taggart Brothers Company, Inc., and the machine shop and engineering laboratory of St. Regis Paper Company. The party will remain in Oswego overnight, returning to New York on Saturday.

## Indianapolis Outlook Encouraging

[FROM OUR REGULAR CORRESPONDENT]

INDIANAPOLIS, Ind., September 23, 1935—Paper demand continues to hold the gains made immediately after Labor Day and the entire trade is encouraged. Inquiries are heavy, indicating additional business before the end of the month. From all signs the entire base of the trade is expanding. There seem to be more individual customers in the field than there have been for some time. Credit conditions have improved and some jobbers report more spot cash business is being done than for months.

Perhaps there is more uncertainty among the converters here than in any other line. Not that volume is slumping, but prices are. Those from this section who attended the meeting last week at Cleveland returned with the same story. All attending the Cleveland meeting agreed that prices were not being held to a point where adequate profits could be made, but none seemed to have a solution. Volume among the converters here is considerably higher than last year and indications point to further increases, but as one said, "if some of them are making any money, they just haven't figured all their costs. Mill prices continue to hold steady, but we don't seem able to keep ours in the same position."

Sales of fine paper continue good. An increasing volume of direct mail business is reported and cooler weather will bring further increases. Printers report a lot of work being figured and a fair average certain to go through.

The box factories are having a fair business, though some report spottiness. Prices in this field are fairly well held. Demand from automobile, hardware and textile industries is holding even and there has been an increase in the call from candy factories. Inquiries are being received for holiday merchandise and this trade will start soon, with every indication of a larger volume than last year.

Newsprint continues in good demand, prices being steady and lineage showing a healthy increase over the same period a year ago. The country paper particularly seem to have shown an increase. No change has been seen in the paper stock field. Mills are taking more commone grades both of papers and rags than has been the rule.

## Edward S. Lawler Dead

Edward S. Lawler, aged 70, who was widely known in the pulp and paper industry and who died recently, was buried September 8 at Bellows Falls, Vt.

While Mr. Lawler was not the first, he was among the first sulphite pulp foreman in America, starting this work in the sulphite pulp mill at Bellows Falls, Vt., when it was built about 1888. He was best known as the sulphite expert of the International Paper Company which position he held from 1910 until he retired in 1929.

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## INDUSTRY URGED TO STUDY LEGISLATION

"We are steadily confronted with an almost continuing attempt to evade the plain limitations placed upon the exercise of political power," says James A. Emery, chief counsel of the National Association of Manufacturers in a letter to members. He expresses the opinion that we face evident determination to evade by indirection what centuries of experience has written into constitutional prohibitions against doing directly.

Mr. Emery sees in the proposals for a new NRA, and in the Walsh bill affecting employer-government contracts, the reflection of a "continuing determination to use all the tremendous power of compulsion which the Federal government may invoke to establish indirectly a general regulation of hours, wages, and working conditions through the instrumentality of Government contracts, loans, and grants."

Within the provisions of the Walsh bill, Mr. Emery foresees the Federal government, in a strongly entrenched creditor position over states as well as corporations, to use its sovereign power "to regulate, as the Executive may choose, hours, wages, and working conditions for all employers dealing directly with the Federal government or with all States and subdivisions thereof, which borrow from the National Treasury, by requiring through them, as well as all primary contractors, that the subject matter of all public contracts shall be produced under discretionary Executive stipulations.

"The impracticability of executing Government and non-Government work under differing standards of hours, wages, and working conditions in the same shop," Mr. Emery points out, "becomes the means through which the Federal government would regulate, upon its own terms, not only the work done directly for it but all work for the States and their remotest subdivisions carried on through its credit."

Industry's attention is directed particularly to the O'Mahoney bill regulating business through licensing corporations in interstate and foreign commerce. In its provisions Mr. Emery finds "the complete, detailed control of employment relations throughout the United States effected through a permit system and enforced by the Federal Trade Commission which is authorized to exclude the offending corporation from such commerce for non-compliance with its conditions.

"If that principle is sound," Mr. Emery continues, "no feature of corporate activity is beyond immediate and drastic control through the continuing amendment of license. Every private right and all local law would disappear in the all-embracing grasp of Federal power." He states that sponsors of the bill were proceeding on the theory that its provisions could be carried out without Constitutional amendment.

There are pending, Mr. Emery points out, both bills and suggestions "to impair the jurisdiction of the Federal courts and thus cripple their protective and remedial powers. Back of these remain proposed constitutional amendments, the most drastic of which would lodge in the Congress the power to fix hours, wages, and working conditions for the nation."

Industry, he says, is confronted not merely with the immediate problem of administrative adjustment to enacted legislation, but as well with continuing preparation to meet pending suggestions of policy vitally affecting all industry.

Among these he lists a variety of investigations to be pursued with respect to "the communication industries, the railroads, the relations through processors of agriculture and manufacture, the activities of chain stores and the continuation of inquiries into the nature and extent of alleged deviations from former code standards and requirements under the NRA. With reference to the last, some 3,000 employees still constitute the so-called "skeleton force," compiling and tabulating information."

Industry is urged to lend its support to measures presented in both the Senate and House of Representatives that would "compel the Government to abandon methods of competition condemned alike by its administrative agencies and our courts, and to establish cost-accounting systems for Government agencies under the direction of the Comptroller General." Such a procedure, Mr. Emery states, "provides the only accurate and practicable means yet suggested for determining comparable Government and private costs of operation through universally accepted standards of accounting."

Likewise, industry is asked to study carefully legislation that "enlarges the power of labor combinations, while relieving them of any control for the protection of the public or any liability for their own acts or those of their clients. There is no equality in bargaining power where one party is within and the other without the law. . . . The issue is not whether we shall have labor organizations but whether the worker shall freely determine whether or not any particular form of association will better advance his interest, what form, if any, he desires, and what responsibility such organizations shall have to him, to those

with whom they deal, and to the public. . . . There is no place in American life for irresponsible power."

Employers are advised to clarify the problems of industry to their employees in order that they may perceive more clearly their stake in the future of a particular enterprise. Companies which have followed such a procedure, Mr. Emery says, have shown "remarkable success in contributing to the removal of the innuendos and suspicions that have been directed against business management." He further advises that shareholders also be instructed in the problems of industry, particularly in view of the fact that employer, employee, and shareholder are all affected now by the "supervising, regulating, and taxing power of government."

"The 'breathing spell' before us," Mr. Emery concluded, "is one in which to inform and direct public opinion to the significance and destructive effect of proposals plainly and practically in flat contradiction with all our traditions and experience. They threaten alike the rights and just interests of every man who has a job, a savings account, a farm, an insurance policy, a share of stock in any enterprise, or hopes to possess any or all of these for himself or his children."

## Rushmore Mills Completing Improvements

[FROM OUR REGULAR CORRESPONDENT]

GOUVERNEUR, N. Y., September 23, 1935—Improvements at the Rushmore Paper Mills are rapidly nearing completion and officials report everything running smoothly. Although no definite time has been fixed for the reopening it is understood that as soon as the new finishing room and warehouse plant is completed all arrangements will be made. The structure will probably be completed within two weeks. The work on the railroad spur running into the mill has virtually been completed but several days more will be required to finish the task of laying new ties on the trestle in the yard. Following the reopening it is expected that many tenements owned by the company will be remodeled for the benefit of the mill workers.

Equipment for the plant is arriving here nearly every day and during the past week two freight cars loaded to capacity reached here. This machinery consists of the parts of the paper machine which the Bagley & Sewall Company is remodeling. The Watertown concern constructed the paper machine which was housed in the mill when the new owners acquired the property from the Oswegatchie Paper Company. The machine is being reconstructed in order to produce special grades of paper.

## Miami Valley Superintendents Meet

DAYTON, OHIO, September 23, 1935—A large number of mill men from various sections of the Miami Valley attended the opening meeting of the 1935-36 monthly schedule of the Miami Valley Division of the American Pulp and Paper Mill Superintendents' Association, at the Elks Country Club near Hamilton, Saturday night. A golf tournament in the afternoon was followed by a business session. Alexander Thomson, president of the Champion Paper and Fibre Company, and Fred C. Boyce, one of the founders and the first president of the Superintendents' Association, were the principal speakers. The latter was the guest of honor.

## Weekly Production Ratio Report

Reports to the American Paper and Pulp Association show the following Over-All Production Ratios for the designated periods:

| | | Reporting Mills Number | Capacity | Total Production Ratio |
|---|---|---|---|---|
| September | 1934 | 292-299 | ..... | 59.4% |
| October | 1934 | 297-394 | ..... | 64.7% |
| November | 1934 | 385-399 | ..... | 61.7% |
| December | 1934 (a) | 396-404 | ..... | 62.1% |
| January | 1935 | 397-411 | ..... | 65.8% |
| February | 1935 | 407-409 | ..... | 70.0% |
| March | 1935 | 406-408 | ..... | 70.5% |
| April | 1935 | 405-407 | ..... | 70.0% |
| May | 1935 | 380-407 | ..... | 69.4% |
| June | 1935 | 356-375 | ..... | 72.2% |
| July | 1935 (b) | 356-357 | ..... | 67.8% |
| August | 1935 | 342-353 | ..... | 70.8% |
| *Week ending | September 7, 1935 (c) | 322 | 115,461 | 77.3% |
| *Week ending | September 14, 1935 | 257 | 106,919 | 70.7% |

Statistics showing the number of mills reporting by ratio groups are given below:

| Ratio Limits | NUMBER OF MILLS REPORTING Week ending September 7, 1935 | September 14,1935 |
|---|---|---|
| 0% to 50% | 91 | 76 |
| 51% to 100% | 231 | 181 |

*Subject to revision.

According to reports from the National Paperboard Association per cents of operation, based on "Inch-Hours" were as follows:

| | | | | | |
|---|---|---|---|---|---|
| | September | 1934.....62% | June | 1935.....65% |
| | October | 1934.....63% | July | 1935.....59% |
| | November | 1934.....56% | August | 3, 1935.....66% |
| (a) | December | 1934.....53% | August | 10, 1935.....64% |
| | January | 1935.....61% | August | 17, 1935.....65% |
| | February | 1935.....67% | August | 24, 1935.....67% |
| | March | 1935.....67% | August | 31, 1935.....69% |
| | April | 1935.....61% | September | 7, 1935.....61% |
| | May | 1935.....61% | September | 14, 1935.....72% |

(a) Capacity and percentage data exclude December 25, 1934.
(b) Capacity and percentage data exclude July 4, 1935.
(c) Capacity and percentage data exclude September 2, 1935.

Revised statistics covering delinquent mill returns will be shown in later reports.

## Newsprint Production in Norway Higher

Newsprint production in Norway is estimated to have shown a further expansion during the second quarter of this year according to a report from American Vice Consul Walter C. Dowling, at Oslo.

The output of other classes of paper is also understood to have increased, although not in proportion to newsprint. Exports of newsprint during the first six months of this year showed a rise of 22 per cent compared with the first half of last year.

Shipments to the United Kingdom, which is the leading market for this class of paper, were practically unchanged, but exports to other important markets, including this country, were generally higher. Of particular interest is the recent increase in exports to South America after the continued decline during the past several years. While market conditions generally much improved, newsprint prices showed no change during the quarter.

## Germany's Pulp Imports Increase

Imports of chemical pulp into Germany during the first six months of this year amounted to 73,130 metric tons as against 65,692 tons during the same period of last year while exports during the same period dropped from 156,550 tons to 145,612 tons, according to unofficial reports reaching the Department of Commerce.

Sweden supplied over 60 per cent of the imports, the remainder coming mostly from Finland and Norway. The United States was a leading country of destination for exports, 38,160 tons being shipped here compared with 35,594 tons going to France. Other important customers were the United Kingdom, Italy and the Netherlands. Germany's imports consist almost wholly of sulphate pulp while exports are sulphite pulp.

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Section of the
Technical Association of the Pulp and Paper Industry
Edited by Ronald G. Macdonald, Secretary

# Drying of Pulp and Paper*

## II. Effects of the Principal Variables on the Rate of Air Drying

By D. W. McCready[1]

**Abstract**

*In this article, data are presented that show the effects of the principal variables of air drying processes on the drying rate curve of a pulp slab. The variables considered are the thickness, density and porosity of the slab, and the temperature, humidity and velocity of the air stream. The effects of these variables are shown by the changes they produce in areas under drying rate curves. As these areas increase the total times required to dry a slab decrease.*

The mechanism of air drying of pulp slabs was presented in the first article of this series *(3)*. With this mechanism known, further considerations of air drying processes are concerned with the effects of drying variables on the rate of drying, and the application of this information to the design and operation of drying equipment. The variables considered here are, the thickness, density and porosity of the slab, and the temperature, humidity and velocity of the drying air.

It is not considered necessary to discuss wet and dry bulb thermometry, relative and absolute humidity, and the transfer of heat and water vapor through slabs and from surfaces to air streams, as these subjects are detailed in texts on Chemical Engineering *(1)*. Also the details of drying rate curves and definitions of terms used in this article are given in the previous article *(3)*.

The experimental procedure was simple. Slabs of kraft pulp or asbestos were formed on a laboratory sheet mold and then pressed to the desired dimensions. These slabs were hung in a stream of conditioned air, and as they dried, weight-time data were taken. The drying rate curve was calculated and plotted.

### Previous Work

The literature contains considerable data on the relative effects of drying variables on the total drying times of pulp slabs. Most of these data are of little value, as only small amounts of the data were correlated with the mechanism of drying. Lewis, McAdams and Adams *(2)* and Sherwood *(5) (6) (7)* correlated their data with their suggested mechanisms of drying, and McCready and McCabe *(4)* used data on the effects of the principal variables on the rate of drying to explain the mechanism of adiabatic air drying of hygroscopic materials.

### The Drying Rate Curve

Drying rate curves are obtained from experimental data by plotting instantaneous rates of drying as ordinates versus average water concentrations of the solid as abscissas. The curve in the interval of constant rate drying is parallel to the abscissa; in the interval of falling rate drying, the rate of drying decreases as the average water concentration of the slab decreases, and the curve intercepts the abscissa at a water concentration equal to the equilibrium water concentration of the slab.

The rate of drying in the interval of constant rate drying may be equated as the rate of diffusion of water vapor from a saturated air-solid interface to the unsaturated air stream, as free water is present at the surface of the slab. This is a well-known relationship, which states that the weight rate of water diffusion per unit area of surface is proportional to the aqueous diffusivity and partial pressure difference between the surface and the air stream (1) (5). [2]

$$\frac{dw}{d\theta A} = k_g (p_s - p_a) \qquad (1)$$

Under adiabatic conditions $p_s$ equals the vapor pressure of water at the wet bulb temperature of drying air.

In a similar manner, the rate of drying in the interval of falling rate drying, when water vaporizes in the interior of the slab, may be equated as the rate of diffusion of water vapor from the limit of the zone of vaporization to the air stream. Assuming that the slab contains a negligible bound water content, and also that the aqueous vapor diffusivity is constant through the zone of vaporization, an approximate equation may be written for the rate of drying in the interval of falling rate drying.

$$\frac{dw}{d\theta A} = k_g (p_s - p_a) = \frac{k_m}{L} (p_s - p_a) = K (p_s - p_a), \qquad (2)$$

where

$$K = \frac{1}{\frac{1}{k_g} + \frac{L}{k_m}} \qquad (3)$$

It is obvious that Equation 2 cannot be used in calculat-

* Presented at the fall meeting of the Technical Association of the Pulp and Paper Industry, Ambassador Hotel, Atlantic City, N. J., Sept. 18-21, 1935.

[1] Member TAPPI. Assistant Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich.

[2] A table of nomenclature is given at the end of the article.

ing rates of drying in the interval of falling rate drying, as the quantities $p_s$, $p_a$ and L cannot be determined. But these equations aid in the discussion of the effects of drying variables on drying rate curves.

As there are no simple or accurate formulations of the drying process, the total time required to dry a slab is obtained by integrating a drying rate curve. This can easily be done by graphical integration. Therefore the effects of the principal variables on the drying process are clearly presented by consideration of the changes they produce in the drying rate curve of a slab. It is evident that at higher rates of drying, the ordinates of the drying rate curve will be longer, and consequently the area under the drying rate will be larger. The total time required to dry a slab varies in an inverse relation to the area under the drying rate curve.

**Effect of Drying Variables on Drying Rate Curves**

EFFECT OF SLAB THICKNESS:

In Fig. 1 are plotted drying rate curves of slabs of kraft pulp that were similar in all respects except thickness. The slabs were dried under the same drying conditions. Increasing slab thickness changes the shape of the drying rate curve, in the interval of falling rate drying, from a curve concave downwards for thin slabs, to a curve concave upwards for thick slabs. This is consistent with the mechanism of drying, for if two slabs with the same properties except thickness are drying at the same rate, the zones of vaporization in each will have the same dimensions. The zone of vaporization in the thin slab will be a larger fraction of the total slab than that of the thicker slab, and as the water concentration in the zone of vaporization is less than the water concentration in the remainder of the slab, the thinner slab will have a smaller average water concentration.

The area under the drying curve decreases as the thickness of the slab increases and the total time required to dry a unit weight of slab increases. Integration of the drying rate curves between T=1.55 and T=0.30 gave elapsed times for Runs 112K, 110K, and 111K of 65, 100 and 240 minutes, respectively. The total drying times or even the relative drying times may be equated as functions of the thickness of the slab, but such equations are useless as they are wholly empirical and of value only for slabs with properties similar to those used in the experiments.

EFFECT OF DRY DENSITY OF SLAB:

In Fig. 2 the drying rate curves of slabs of kraft pulp of varying dry density are plotted. The slabs varied in thickness also as the same amount of pulp was used in each. Both slabs were very porous and both shrank the same during drying. The noticeable effect is the change in the critical water concentration, which becomes less with increasing dry density of the slab, and as a consequence the entire drying rate curve is shifted. The variation of critical water concentration with dry density is explained later by Equation 4. It is evident that the time required to dry slabs of the same face area and weight of dry pulp increases as the dry density of the slab decreases.

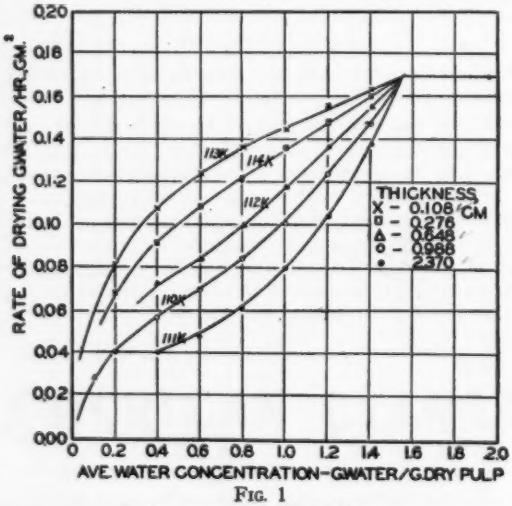


FIG. 1

Drying curves—varying thickness.

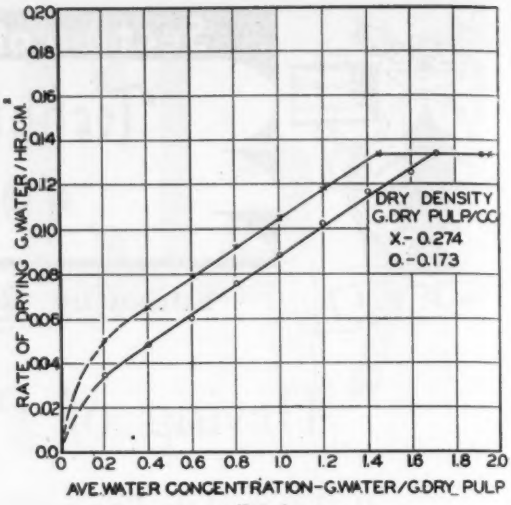


FIG. 2

Drying curves—varying dry density of slab.

EFFECT OF THE RELATIVE HUMIDITY OF THE AIR:

In Fig. 3 are plotted the drying rate curves of pulp slabs which show the effect of changing the relative humidity of the drying air. All other variables remained constant. A decrease in the relative humidity of the air increases the difference between the aqueous vapor pressure at the wet bulb temperature and the aqueous vapor pressure of the water in the drying air.

During the interval of constant rate drying, the rate of drying is proportional to the vapor pressure difference. (See Equation 1). This proportionality continues throughout the drying process (see Equation 2). Thus, when the

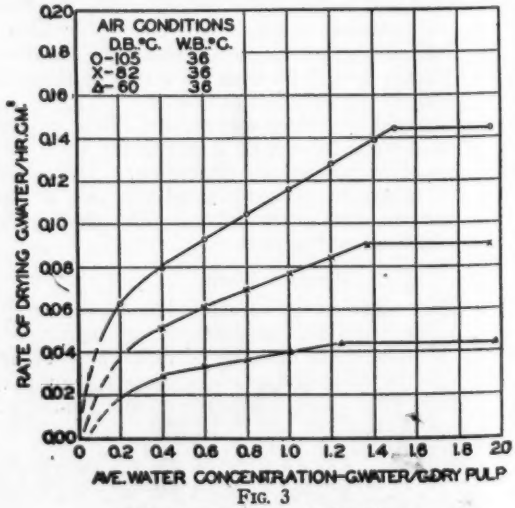


FIG. 3

Drying curves—varying air humidity.

relative humidity of the drying air is changed, all the ordinates of the drying rate curve are changed by amounts that are proportional to the amount of change of the ordinates in the interval of constant rate drying. The rates of drying in the interval of constant rate drying are readily calculated by Equation (1), so that drying rate curves for different humidities of drying air can be obtained. This relationship is very important in the consideration of most drying processes where air conditions are not constant throughout the drier.

EFFECT OF THE VELOCITY OF THE AIR STREAM:

In Fig. 4 are plotted drying rate curves of asbestos slabs which were dried in air streams of varying velocity. A change in air velocity changes the coefficient $k_g$; $k_g$ increases with increasing air velocity. As shown in Equation (1), the rate of drying in the interval of constant rate drying varies proportionally with the value of $k_g$. But in the interval of falling rate drying $k_g$ is only part of the overall coefficient K (Equations 2 and 3) and the effect of increasing $k_g$ becomes less as the value of L increases; or as the drying process proceeds. Therefore the effect of increasing air velocity may be negligible in the last stages of the drying process.

Changing the air velocity changes the ordinates of the drying rate curve in the interval of constant rate drying and a similar relative effect is approximately produced in the first part of the interval of falling rate drying. The curve in the interval of falling rate drying becomes more concave upwards as the air velocity is increased.

EFFECT OF POROSITY OF THE SLAB:

The same effect that is produced on the drying rate curve by changing air velocity is also produced by decreasing the porosity of the pulp slab. In the latter case $k_m$ decreases as the porosity of the slab decreases and this causes drying rate curves to become more concave upwards. This is evident in the drying rate curves illustrated in the first article of this series *(3)*.

### The Critical Water Concentration

One of the most important parts of the drying rate curve is the break between the intervals of constant and falling rate drying at the critical water concentration. This break occurs, when the free water concentration in the slab falls below the minimum necessary to maintain a rate of flow of free water to the surface of the slab, equal to the rate of drying in the interval of constant rate drying. At the critical water concentration the slab contains the maximum bound water content which is a definite weight proportion of the material in the slab. The slab will also contain free water in the voids and the concentration of this water is best expressed on a volume basis. Thus:

$$T_{cp} = Q_s + \frac{F_{cp}}{D_{cp}} \qquad (4)$$

Assuming $Q_s$=1.0 g./g. dry pulp, the free water concentrations of the pulp slabs at the critical water concentration were calculated by Equation (4) and plotted against the rate of drying in the interval of constant rate drying in Fig. 5. This plot gives the important relationship between the rate of drying in the interval of constant rate drying and the free water concentration at the critical water concentration.

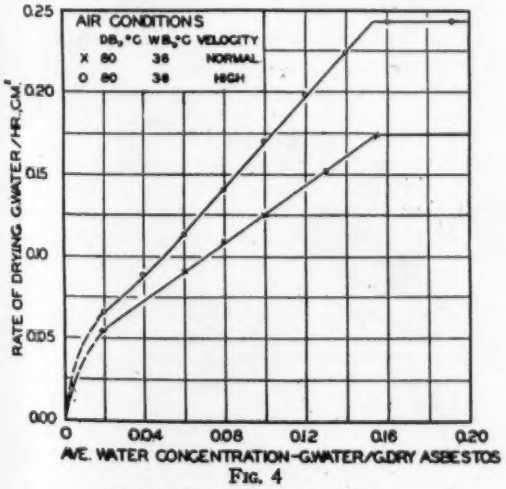


FIG. 4

Drying curves—varying air velocity.

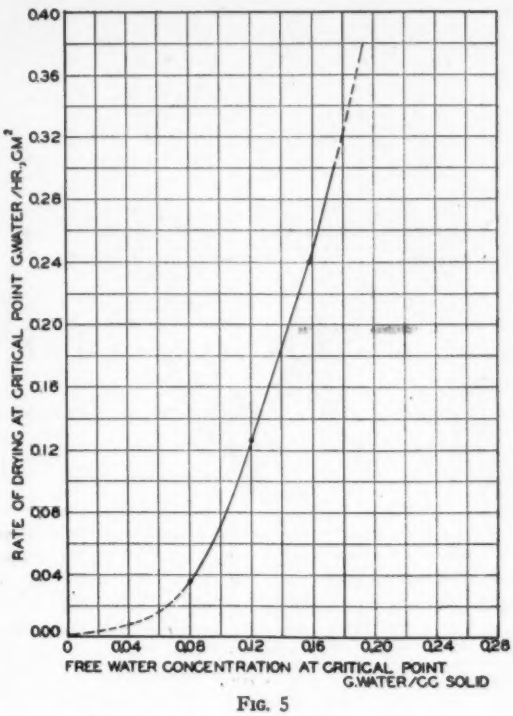


FIG. 5

Drying rate vs. free water conc. at critical point.

### Drying Thin Sheets of Paper

The data presented were obtained on rather thick slabs of pulp, as experimental procedure on thin sheets is very difficult. In the case of thick sheets, it is necessary to have experimental drying rate curves before calculations can be made on drier design and operation. In the case of thin sheets, although the critical water concentration must be above 1.0 gram per gram dry pulp, actual decreases in the rate of drying in the first part of the interval of falling rate drying are small, so that apparent critical points are observed at water concentrations less than 1.0 gram per gram dry pulp. Thus, the critical water concentration may be assumed to approximate 0.60 with little error *(6)*. It follows that the drying rate curve in the interval of falling rate drying will approximate a straight line, and if this is assumed, calculations of drying times of thin sheets of paper are greatly simplified.

### Nomenclature

| Symbol | Name | Units |
|---|---|---|
| A | Drying Area | cm.² |
| $D_{cp}$ | Dry Density at Critical Point | grams dry material per cc. of slab |
| $F_{cp}$ | Free Water Concentration at Critical Point | grams water per cc. of slab |

| Symbol | Name | Units |
|---|---|---|
| $k_g$ | Coefficient of Water Vapor Diffusion between Solid and Air Stream | grams per hour, cm.², mm. Hg. |
| $k_m$ | Specific Coefficient of Water Vapor Diffusion through Solid | grams cm. per hour, cm.² mm. Hg. |
| K | Overall Coefficient of Water Vapor Diffusion | grams per hour, cm.², mm. Hg. |
| L | Distance from Slab Surface to limit of Zone of Vaporization | cm. |
| $p_a$ | Aqueous Vapor Pressure in Drying Air | mm. Hg. |
| $p_s$ | Aqueous Vapor Pressure at Surface of Slab | mm. Hg. |
| $p_z$ | Aqueous Vapor Pressure at Limit of Zone of Vaporization | mm. Hg. |
| $Q_s$ | Maximum Bound Water Concentration | grams per gram dry material |
| T | Average Water Concentration of Slab | grams per gram dry material |
| $T_{cp}$ | Average Water Concentration at Critical Point | grams per gram dry material |
| $\theta$ | Time | hours |
| w | Weight of Water | grams |

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# Drying of Pulp and Paper*

## III. Mechanism of Drying of Pulp Slabs on Heated Surfaces

By D. W. McCready[1]

**Abstract**

*Experimental data are reported on the rate of drying of pulp slabs in contact with hot surfaces under experimental conditions similar to conditions in drum drying processes. The mechanism of drying of the slab is presented which describes the temperature, aqueous vapor pressure and water concentration gradients in the slab during drying under various drying conditions. The effects of slab thicknesses, hot surface temperatures and drying air conditions on the rates of drying are presented,.*

The mechanism of drying of pulp slabs on heated surfaces is of interest because practically all paper is dried under similar conditions on the drum driers of paper machines. The drying operation completes the process of paper making by changing a wet plastic web of pulp fibers into a final rigid sheet of paper. Several properties of the paper depend upon conditions of the drying operation because irregularities such as cockles, curl, color burning and poor sizing are not characteristics of the wet web entering the drying section. The shrinkage of the wet web in a direction normal to the web surfaces is the final factor that contributes to the ultimate physical characteristics of the paper. It is therefore important to understand the means by which paper dries, in order to properly operate and design drying sections of paper machines.

In a previous article of this series (*3*), the mechanism of adiabatic air drying of pulp slabs was presented. This article reports data obtained by drying pulp slabs in contact with a heated surface. The mechanism by which the slabs dry is presented. The terms used in this article are defined in the previous article.

### Previous Work

It is not considered necessary to review the general principles that apply to drying processes (*1*), nor the discussions of the mechanism of air drying of solids (*3*) (*4*) (*7*) (*8*) (*9*). Many investigators have reported data on drying processes in which heat is supplied to the solid from hot surfaces, but a mechanism of drying of the solids under these conditions has not been presented. Lewis, McAdams and Adams (*2*) analyzed data obtained on the drying of paper pulp on drum driers. Sherwood (*8*) presented a means of calculating the influence of heat inflow through non-drying faces on the rate of drying. Stacey (*12*) and Sherwood and Cumins (*11*) have reported and discussed data on the drying of various materials in pans, which method is similar to drying on heated surfaces.

### Cases of Drying

When a wet slab is dried with one face in contact with a surface that is impermeable to water and at a higher temperature than the slab, and the other slab face is exposed to a stream of drying air, the means by which heat is supplied to the slab in any period of the drying process, depends upon the shape of the temperature gradient between the hot surface and the drying air. There are two general cases:

Case I. A continuously decreasing temperature gradient extends from the hot surface, through the slab, to the drying air.

Case II. The temperature gradient between the hot surface and the drying air passes through a minimum temperature in the slab and increases to the temperatures of the hot surface and the drying air.

A third case, where the minimum temperature in the slab equals the temperature of the drying air, is not considered as it is similar to Case I.

In Case I drying, all the heat required for the drying process is supplied from the hot surface, including sensible heat transferred from the slab to the drying air. In Case II drying, heat is supplied to the slab from both the hot surface and the air stream; the latter amount of heat is supplied directly to the open face similar to the conditions during adiabatic air drying.

### Mechanism of Drying of Slabs in Contact with Hot Surfaces

The mechanism by which a slab dries depends upon the distribution of the temperature and aqueous vapor pressure gradients through the slab. In the experimental work, temperatures in the drying slabs were measured. The mechanism of drying suggested modifies the concepts that were used in the discussion of the mechanism of adiabatic air drying (*3*) (*4*), to account for the changes induced in the temperature and aqueous vapor pressure gradients, by the flow of heat into the slab, through a surface that is impermeable to water.

INTERVAL OF CONSTANT RATE DRYING:

A slab dries at a constant rate as long as the aqueous vapor pressure difference between the air-slab interface and the stream of drying air remains constant. During the interval of constant rate drying free water is present in all planes in the slab. The atmosphere at the air-slab interface is saturated with water vapor and the aqueous vapor pressure at this plane equals the vapor pressure of water at the temperature of the interface. This tempera-

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ture remains constant. The interval of constant rate drying terminates when the free water concentration at the air-slab interface becomes zero, or when the temperature of the interface decreases if free water is present.

In Case I drying, due to the continuously decreasing temperature gradient between the hot surface and the drying air, the minimum temperature in the slab is at the open face.

In Case II drying, conditions at the open face of the slab are similar to those at the face of a slab drying adiabatically in a stream of air; that is, the air stream is at a higher temperature than the slab face and heat flows from the air stream to the slab. Under these conditions, the minimum temperature in the slab must be at the open face, because an increasing temperature gradient, between a plane within the slab and the drying air, is a characteristic of a zone of vaporization which would extend between the location of the minimum temperature and the open face. And a zone of vaporization appears only after the free water concentration at the slab face becomes zero, which occurs at the termination of the interval of constant rate drying.

In both Cases I and II drying, due to the temperature differences, heat is transferred from the hot surface to the slab, through the slab, and between the slab and the drying air. These temperature differences are constant in the interval of constant rate drying, and the total heat used in the slab to vaporize water is the sum of the heat inflows from the air stream and hot surface.

The rate of drying equals the rate of diffusion of water vapor from the saturated air-solid interface to the air stream.[2]

$$S = \frac{d\,w}{d\,\theta\,A} = k_g\,(p_s - p_a) \qquad (1)$$

Due to the decreasing temperature difference between the closed and open faces of the slab, the aqueous vapor pressure is greater at the closed face than at the open face, and water vapor can diffuse through the slab.

The water vapor that diffuses from the open face is the sum of the water vaporizing at this face and the water vapor diffusing through the slab. As the atmospheres in all planes inside the slab are saturated with water vapor, water cannot readily vaporize inside the slab. The diffusion of water vapor through the slab tends to deplete the concentration of water vapor in the atmosphere at the closed face, and experimental results indicate that all the water vaporizing beneath the open face vaporizes at the closed face. Thus it can be considered that during the interval of constant rate drying, water vaporizes at two places, at the closed and at the open faces of the slab.

INTERVAL OF FALLING RATE DRYING:

The interval of falling rate drying is characterized by the retreat of the locus of vaporization of water from the surface of the slab into the interior of the slab. The slab is divided into zones, a free water zone that contains free water and the maximum amount of bound water, and zones of vaporization that contain only bound water and in which water vaporizes. A zone of vaporization is characterized by an increasing temperature gradient between the limit of the zone of vaporization and the face of the slab from which the locus of vaporization retreated, and a decreasing aqueous vapor pressure gradient or relative humidity gradient over the same distance. At any point in the zone of vaporization the humid air and pulp are substantially in equilibrium, and the moisture content of the pulp is indicated by the data presented in the relative humidity-water content, desorption curve of the pulp.

In Case I drying, due to the continuously decreasing temperature gradient between the closed and open faces of the slab, the only place a zone of vaporization may form is beneath the closed face. Conditions within the slab, at a time during the interval of falling rate drying, but before all the free water is vaporized, are represented as ordinates in Fig. 1 and plotted versus distances from the heated surface to the air stream. The zone of vaporization extends from the closed face to the limit of the zone of vaporization, and the remainder of the slab is in the free water zone. The total temperature difference, $t_p$-$t_a$, between the heated surface and the drying air is divided into separate temperature drops through the specific parts of the system. Heat flows from the heated surface to the closed face of the slab through the air film between the surface and the slab. Part of this heat is used in vaporizing water in the zone of vaporization and the remainder is transferred through the free water zone to be used in part, possibly, for the vaporization of water at the open face and to be lost to the air stream as sensible heat. In the zone of vaporization, the water concentrations are less than the maximum bound water content, $Q_z$, and in the free water zone, greater. The area between the water concentration gradient and the value of $Q_z$ in the free water zone indicates the amount of free water in the slab. The aqueous vapor pressure throughout the zone of vaporization, $p_z$, is constant and equal to the vapor pressure of water at the temperature, $t_z$, of the limit of the zone of vaporization; as this zone is bounded by a surface impermeable to water and the saturated atmosphere at the limit of the zone of vaporization. The water concentration gradient decreases between the limit of the zone of vaporization and the closed face due to the decreasing relative humidity gradient over the same path. The aqueous vapor pressures in planes in the free water zone equal the vapor pressures of water at the temperatures of these planes. The atmospheres in the free water zone are saturated with water vapor and therefore water

[2] A table of nomenclature is placed at the end of the article.

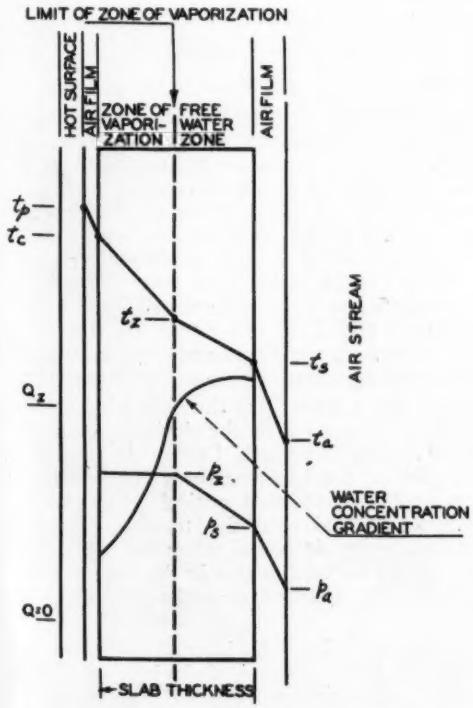


FIG. 1

Case I drying, conditions in slab during interval of falling rate drying.

does not vaporize in this zone. Free water may flow to and vaporize at both the limit of zone of vaporization and the open face of the slab. Water vapor formed in the zone of vaporization diffuses through the free water zone so the material in the free water zone is always in contact with a saturated atmosphere and therefore does not dry. As the drying process proceeds, the limit of the zone of vaporization moves through the slab to the open face and after reaching the open face, only bound water remains in the slab. Or drying may change from Case I to Case II type.

In Case II drying, due to the location of the minimum temperature in the slab, two zones of vaporization may form, one beneath the closed face of the slab as explained above, and the other beneath the open face of the slab, similar to the zone of vaporization formed during adiabatic air drying (*3*). Free water is not present at the open face of the slab. The limits of these zones of vaporization will meet within the slab in the last period of the drying process, after which only bound water remains in the slab.

The layer of dried pulp in the zone of vaporization beneath the closed face decreases the thermal conductivity of the slab and as this layer increases in thickness temperatures in the slab decrease. The flows of heat and water vapor, from the closed face to the plane of minimum temperature in the slab, are concurrent and parallel. In these respects, the mechanism of drying of slabs on heated surfaces differs from the mechanism of adiabatic air drying of slabs, for during adiabatic air drying, temperatures in the slab increase after the critical water concentration, and the flows of heat and water vapor are opposite and parallel.

### Experimental Procedure

The slabs used in the drying experiments were made from raw fiber stock. Separate plies were made on a laboratory paper sheet mold and these plies were assembled to form the slab. Copper-constantan thermocouples made of 32 gauge enameled wire, were placed between the plies and surface thermocouples were placed under thin plies, 0.002 inches thick. The plies were built up on the hot plate which was a piece of 19 gauge copper sheet, 14 cm. diameter. Twelve pointed spikes, ½ inches long and 1/16 inch in diameter, were fastened to the plate at equal intervals on a circle 13 cm. in diameter. Strips of cellophane were cemented to the edge of the face of the plate so that about ½ inch of cellophane projected beyond the edge of the plate. The plies were the same diameter as the plate and when assembled they were pierced by the spikes. The assembly was pressed in a letter press to form a compact slab of the desired dimensions. The spikes held the slab firmly against the plate. The cellophane strips were cemented to the edge of the sample, and by this means diffusion of water vapor from the closed face and the edges of the slab was repressed.

The plate and slab were suspended from the arm of a balance in a drying cabinet of galvanized iron, size 7 x 4 x 18 inches. The thermocouple leads were taken off at right angles to the face of the sample through a hole in the front of the cabinet. The plate was hung so that it was centered in front of a hole 5 inches in diameter in the back wall of the cabinet and hung so that it just cleared the back wall. A sleeve of sheet iron 5 inches in diameter and 3 inches long extended from the hole in the back wall. The plate was heated by a radiant electrical heater, the radiant heat passed through the sleeve and hole in the back of the cabinet to the back of the plate. The amount of heat supplied was adjusted by varying the distance between the heater and the plate. A large piece of transite board prevented radiant heat from striking other parts of the cabinet. Conditioned air was passed over the exposed face of the sample.

During a run the air conditions and the temperature of the plate remained constant. The data taken gave a weight loss vs. time curve on the drying sample and temperatures in the sample. The times required to evaporate two gram portions of water from the sample were plotted versus the total water in the sample and a curve drawn through the data points. The instantaneous rates of drying at average water concentrations of the sample were readily calculated from this curve and the drying rate curve plotted.

### Experimental Data

The data obtained in Runs 201 and 203 are discussed in detail because these data present experimental confirmation of the suggested mechanism of drying. In Run 201, a slab was dried under Case I drying conditions and in Run 203 under Case II drying conditions. Other runs were made to study the influence of important variables on the drying process. The important drying data on all pulp runs are given in Table I. Data on asbestos run are not reported as the results were similar in all respects to the results obtained with pulp slabs. As the experimental procedure was difficult, the accuracy of the data does not warrant quantitative calculations; however, qualitative deductions can be made.

TABLE I
DRYING RATE OF PULP SLABS

| Run | Plate Temp. deg. C. | Air Dry Bulb Temp. deg. C. | Air Wet Bulb Temp. deg. C. | Initial Slab Dimensions Dia. cm. | Initial Slab Dimensions Thick. cm. | Weight of Dry Pulp, g. | Rate of Drying in Interval of Constant Rate Drying, g./hr., cm.² | Critical water Concentration, g./g. dry pulp |
|---|---|---|---|---|---|---|---|---|
| 201 | 80 | 41 | 18.5 | 14.0 | 0.635 | 22.2 | 0.450 | 1.75 |
| 203 | 80 | 80 | 25.5 | 14.0 | 0.635 | 20.9 | 0.465 | 1.80 |
| 204 | 80 | 40 | 30. | 14.0 | 0.635 | 18.15 | 0.420 | 1.80 |
| 205 | 80 | 40 | 40 | 14.0 | 0.635 | 20.35 | 0.375 | 1.80 |
| 207 | 80 | 40 | 19.5 | 14.0 | 0.381 | 14.15 | 0.580 | 1.45 |
| 210 | 80 | 40 | 17.5 | 14.0 | 0.955 | 29.15 | 0.320 | 1.20 |
| 211 | 80 | 60 | 21.5 | 14.0 | 0.635 | 17.13 | 0.415 | 1.70 |
| 212 | 80 | 40 | 16.5 | 14.0 | 0.635 | 21.4 | 0.245 | 1.67 |
| | | | | | Dry thick. | | | |
| RW6 | 80 | 40 | 21 | 17x17 | 0.270 | 15.64 | 0.445 | 1.75 |
| RW7 | 100 | 40 | 21 | 17x17 | 0.270 | 14.83 | 0.770 | 1.80 |
| RW8 | 120 | 40 | 21 | 17x17 | 0.270 | 14.86 | 1.180 | ... |

CASE I DRYING OF A PAPER PULP SLAB, RUN 201:

A paper pulp slab was dried under conditions such that during the entire drying process the temperature gradient between the hot plate and air decreased continuously. This was Run 201 and the drying data are plotted in Fig. 2. The instantaneous rates of drying of the slab and local temperatures are plotted as ordinates versus the average water concentrations of the slab as abcissa. Temperatures were measured at the following points; $t_p$ was at the surface of the plate in contact with the slab and $t_1$ to $t_6$ were located respectively 2, 21, 40, 59, 78 and 98 per cent of the distance between the closed and open faces of the slab. The dry bulb temperature of the air is plotted as $t_a$.

Study of Fig. 1 shows that the slab dried at a constant rate in the first interval of the drying process and then the rate of drying decreased. During the interval of constant rate drying, local temperatures in the slab remained constant until the indicated critical water concentration was approached, and then the temperatures decreased. The rate of drying decreased when the temperatures decreased, but the initial decrease in the rate was small and the critical point is drawn as a sharp break in order to define it.

In the first period of the interval of falling rate drying, $2.00>T>1.25$, the rate of drying and consequently the rate of heat transfer from the plate to the slab decreased, temperatures in the slab decreased, temperature differences between the plate and the slab increased,

and temperature differences through the slab decreased. These observations indicate that the thermal resistance between the plate and the slab increased due to drying out of the water film between the slab and the plate, and that the thermal conductivity of the slab remained substantially constant and equal to the value of the wet slab in the interval of constant rate drying. In the second period, $1.50>T>1.00$, temperature differences across the first ply beneath the closed face increased, which indicates that this ply was drying, and temperature differences across the remainder of the slab decreased, which indicates that this part of the slab remained wet with a substantially constant thermal conductivity. In the latter part of this period, the decrease in the temperature differences between the plate and the slab indicate that the thermal resistance between these points reached and remained at a substantially constant value, after the water had dried out. In the third period, $1.10>T>0.60$, the thermal resistance of the second ply beneath the closed face increased, due to drying out of water, and the thermal conductivity of the other parts of the slab remained substantially constant.

In this drying run, under Case I drying conditions, a zone of vaporization was formed beneath the closed face of the slab, the limit of the zone of vaporization advanced to the open face of the slab, and between the limit and the open face there was a free water zone. In the zone of vaporization between the closed face and the limit of the zone of vaporization, temperatures decreased, aqueous vapor pressures were equal to the vapor pressure of water at the limit, and relative humidities increased. The water concentration of the material in the zone of vaporization was less than the maximum bound water concentration of 1.0 gram water per gram dry pulp, and the water concentration in the free water zone was greater. This is checked by the data of Roderick and Waldemeyer *(5)*. They found that the water concentrations in plies of a three ply pulp slab, dried under Case I

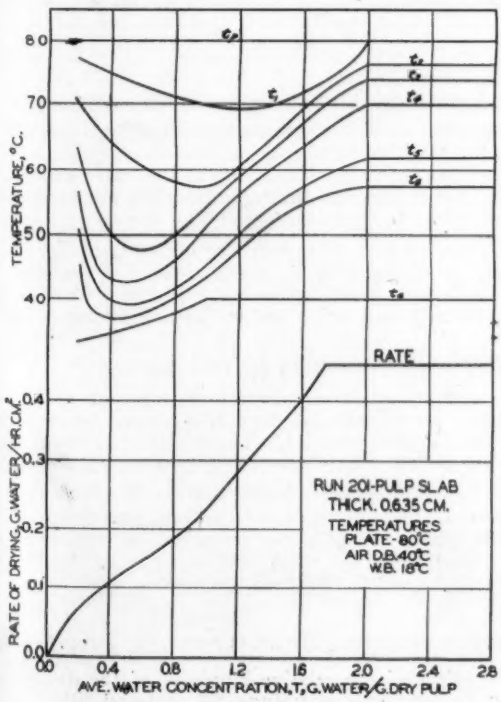


FIG. 2
Drying data—Case I drying conditions.

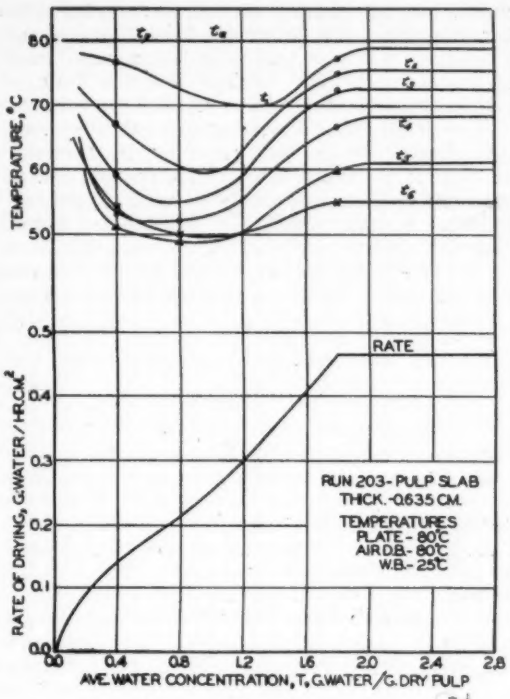


FIG. 3
Drying data—Case II drying conditions.

drying conditions, were 0.374, 1.28 and 1.28 grams water per gram dry pulp respectively for the closed face, middle and open face plies.

The limit of the zone of vaporization must have reached the open face at about $T = 0.50$. While the zone of vaporization was beneath the closed face, the water concentration at the open face was equal to or greater than the maximum bound water concentration of the pulp, and the atmosphere at the air-slab interface was saturated with water vapor. This is indicated by the following calculations. The data of the interval of constant rate drying were substituted in Equation (1) and $k_g$ determined as 0.00357 grams per hour, cm.², mm. Hg. In this calculation $p_a = 4$ mm.; $t_6 = 57$ deg. C., so $p_s = 130$ mm.; and $S = 0.45$. The rates of drying in the interval of falling rate drying were then calculated by equation (1), using $p_a$ and $k_g$ as given above and $p_s$ the vapor pressure of water at $t_6$. The results are given in Table II.

TABLE II
CALCULATED DRYING RATES, RUN 201 AND 203

| Avg. Water Concentration T | Temperature Exposed Face $t_s$ | Aqueous Vapor Pressure $p_s$ | Calculated Drying Rate S | Experimental Drying Rate S |
|---|---|---|---|---|
| | | RUN 201 | | |
| 2.4 | 57 | 130 | 0.45 | 0.45 |
| 1.8 | 56 | 123 | 0.425 | 0.45 |
| 1.6 | 54.5 | 115 | 0.396 | 0.41 |
| 1.4 | 52.0 | 102 | 0.350 | 0.345 |
| 1.2 | 48.0 | 85 | 0.290 | 0.280 |
| 1.0 | 44.0 | 68 | 0.230 | 0.230 |
| 0.8 | 40.5 | 56.5 | 0.188 | 0.185 |
| 0.6 | 37.5 | 48.0 | 0.150 | 0.150 |
| 0.4 | 36.5 | 44.0 | 0.143 | 0.110 |
| 0.2 | 45.0 | 71.0 | 0.240 | 0.065 |
| | | RUN 203 | | |
| 2.4 | 55.0 | 120 | 0.465 | 0.465 |
| 1.8 | 55.0 | 120 | 0.465 | 0.465 |
| 1.6 | 54.0 | 112 | 0.433 | 0.405 |
| 1.4 | 51.5 | 98 | 0.410 | 0.355 |
| 1.2 | 50.0 | 92 | 0.385 | 0.300 |
| 1.0 | 49.5 | 89 | 0.372 | 0.255 |
| 0.8 | 50.0 | 92 | 0.386 | 0.210 |
| 0.6 | 51.5 | 98 | 0.410 | 0.175 |
| 0.4 | 54.0 | 112 | 0.433 | 0.140 |
| 0.2 | 61.0 | 156 | 0.660 | 0.095 |

The calculated rate of drying closely checks the ex-

perimental drying rate at average water concentrations greater than 0.60. Therefore the atmosphere at the air-solid interface was saturated with water vapor until this water concentration was reached, and the limit of the zone of vaporization must have reached the open face at about T = 0.50. That water vaporizes at the closed face is also indicated by the fact that if water vaporized only at the open face, the thermal conductivity of the slab in the constant rate interval would have to be greater than 7.0 Cal., cm. per hour, cm.², deg. C. This is greater than the thermal conductivity of pure water which is 5.6 at 57 deg. C. and 5.95 at 80 deg. C. and the thermal conductivity of the slab must be less than that of pure water.

CASE II DRYING OF A PAPER PULP SLAB, RUN 203:

A pulp slab was dried under conditions such that the temperature gradient between the hot plate and the drying air passed through a minimum temperature in the slab. This was Run 203 and the drying data obtained, which are similar to the data of Run 201, are plotted in Fig. 3.

In the interval of constant rate drying conditions in the slab are similar to those in Run 201. The minimum temperature in the slab is at the open face.

In the interval of falling rate drying conditions at the closed face are similar to those in Run 201. Conditions at the open face differ as the locus of the minimum temperature in the slab retreats beneath the open face at an average water concentration of T = 1.20. Thus, at water concentrations below this value, the conditions in the slab beneath the open face are similar to the conditions in adiabatic air drying *(3)*. A zone of vaporization was formed beneath the open face. The limit of this zone and the limit of the zone of vaporization formed beneath the closed face must have met in the slab at an average water concentration of about 0.60, after which temperatures in the slab increased. That two zones of vaporization were formed is indicated by the data of Russell and Wright (⁶) on the water gradient in a pulp slab, which was dried under conditions similar to Run 203, and removed from the drier when in the interval of falling rate drying. The water concentrations in the plies from the open face ply to the closed face ply were respectively, 0.165, 0.543, 0.655, 0.482 and 0.097 grams water per gram dry pulp.

As a zone of vaporization was formed beneath the exposed face the atmosphere at the air-solid interface was not saturated during the interval of falling rate drying.

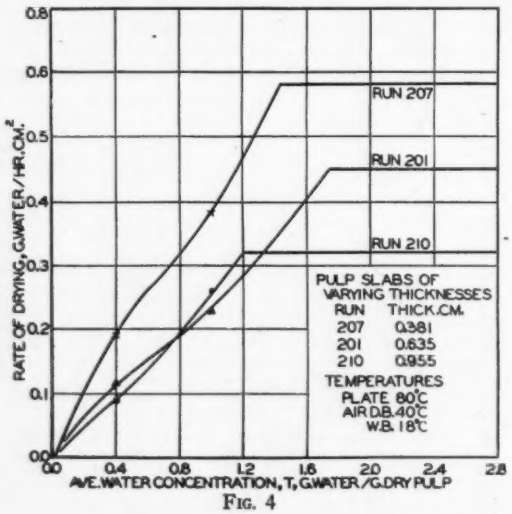


FIG. 4

Drying curves—varying thickness of slab.

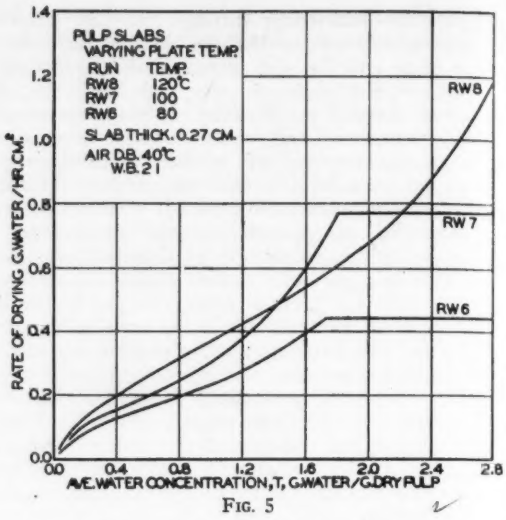


FIG. 5

Drying curves—varying plate temperature.

This is indicated in the comparison of the actual drying rate and the drying rate calculated by the method used in the discussion of Run 201; the values are given in Table II. The rates of drying calculated by assuming a saturated air-solid interface are higher than the actual rates in the interval of falling rate drying, so the atmosphere at the air-solid interface was not saturated after the critical water concentration.

**Effects of Principal Variables on the Drying Rate Curve**

Runs were made to determine the effects of the following variables on the drying rate curves; the thickness of the slab, the air dry bulb temperature, the relative humidity of the air and the temperature difference between the plate and the air. The velocity of the air in all runs was constant. The effects of the principal variables are shown by changes in the rate of drying in the interval of constant rate drying.

EFFECT OF SLAB THICKNESS:

The effect of slab thickness is shown by comparison of Runs 201, 207, and 210, Fig. 4. The thick slabs dried at a slower rate than the thin slabs, as the rates of heat and water vapor transfer through the slabs decrease as the thickness of the slabs increase. The drying rate curve of the thick slab was more concave upwards in the interval of falling rate drying than the curve for the thin slab. The thick slab dried under Case I drying conditions to T = 1.0 and then dried under Case II drying conditions.

EFFECT OF TEMPERATURE OF THE AIR:

The effect of drying air temperature at constant air humidity, on the rate of drying, is shown by comparison of Runs 201, 203 and 211. There was little change in the rates of drying in the interval of constant rate drying and the drying rate curves were similar in the interval of falling rate drying. As most of the heat was supplied from the hot plate, changing the temperatures affected only a small fraction of the total heat supplied to the slab, and therefore had little effect on the drying rate.

EFFECT OF RELATIVE HUMIDITY OF THE DRYING AIR:

The effect of the relative humidity of the drying air is shown by comparison of Runs 201, 204 and 205. The rates of drying in the interval of constant rate drying decreased

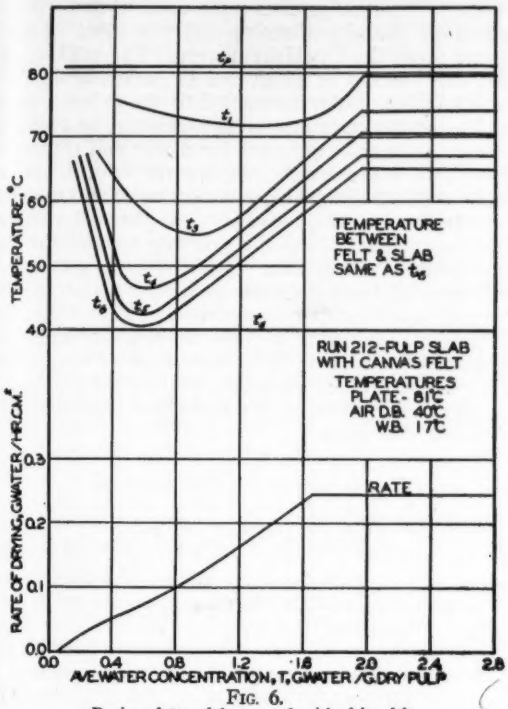
TEMPERATURE, °C
RATE OF DRYING, G WATER / HR. C.M.²
AVE. WATER CONCENTRATION, T, G WATER / G DRY PULP
TEMPERATURE BETWEEN FELT & SLAB SAME AS $t_{fs}$
RUN 212-PULP SLAB WITH CANVAS FELT
TEMPERATURES
PLATE - 81°C
AIR D.B. 40°C
W.B. 17°C
RATE

FIG. 6.
Drying data—slab covered with drier felt.

as the relative humidity of the drying air increased due to the decreases in the aqueous vapor pressure differences between the slab and the drying air. The changes in drying rate are relatively small for most of the heat was supplied from the hot plate. All slabs dried entirely under Case I drying conditions and the drying curves of the slabs in the interval of falling rate drying were similar in shape.

### Effect of Increasing Plate Temperature

The effect of increasing plate temperature is shown by Runs RW6, RW7, and RW8 *(5)* in Fig. 5. Increasing the plate temperature increases greatly the rate of drying. In Run RW8, some water vapor escaped from between the slab and the plate as boiling occurred at the closed face and the seal between the slab and the plate was broken. It is evident that the most important variable in the process of drying slabs on heated surfaces is the temperature of the heated surface.

### Effect of Felt Covering on Drying

In Fig. 6 are plotted the drying data of Run 212 which was made with the open face of the pulp slab covered with a piece of canvas drier felt. The pulp slab and drying conditions were the same as for Run 201, and by comparison of these two runs the effect of the drier felt on the rate of drying can be observed. The rate of drying is greatly decreased. The effect of the felt is to increase the temperature and humidity of the air in contact with the open face of the slab. This method gives a means of determining and comparing the drying properties of drier felts. Of particular interest is the fact that atmospheres in the drier felt are saturated with water vapor.

### Conclusion

The factors that have the greatest influence on the rate of drying of paper are the temperature of the hot surface, the thickness of the paper, and the use of a drier felt. The temperature of the drying air has little effect on the rate of drying, as most of the heat required for the drying process is supplied from the hot surface. Changing the relative humidity of the air has little effect on the rate of drying providing the difference between the hot surface and drying air temperatures is large. Other conclusions regarding the process of paper drying can readily be made using as a basis the suggested mechanism of drying.

### Nomenclature

| Symbol | Name | Unit |
|---|---|---|
| A | Drying Area | cm.² |
| $k_g$ | Coefficient of Water Vapor Diffusion between Slab and Air Stream | grams per hour, cm.², mm. Hg. |
| $p_a$ | Aqueous Vapor Pressure in Drying Air | mm. Hg. |
| $p_s$ | Aqueous Vapor Pressure at Slab-Air Interface | mm. Hg. |
| S | Rate of Drying | grams water per hour, cm.² |
| Θ | Time | hours |
| w | Weight of water | grams |

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# Effect of Temperature and Consistency In Mechanical Pulping*

By E. R. Schafer[1] and J. C. Pew[2]

**Abstract**

*White spruce and loblolly pine pulpwood were ground at various temperatures and consistencies on several types of stone surfaces, in the Forest Products Laboratory two-pocket experimental grinder, under carefully controlled conditions. In general the grinding process is favored by high temperatures, provided excessive pulp consistencies are prevented by the use of warm shower water. High temperatures caused in nearly all cases an increase in grinding rate, a decrease in power consumption, an increase in the strength of the pulp, and a material increase in fiber length and freeness. Increase in the consistency of pulp in the grinder pit above 4 per cent caused an increased power consumption with a decrease in grinding rate. At the consistencies employed the grinding temperature had little effect on the color of the pulp.*

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Although the literature on groundwood pulping is replete with discussions on the effect of temperature, much of it is based on little supporting evidence. The subject is therefore controversial. One article states that increasing the temperature increases the proportion of coarse fibers. Another article states that high temperature causes objectionable flour. A mill operating by the "hot" groundwood process is reported to be producing pulp of excellent quality, but another mill reports that when the temperature was increased the strength decreased. A large part of the difference of opinion as to the effect of temperature is due to the failure to differentiate between temperature as a cause and temperature as an effect. In other words, the variation in results obtained by grinding at two different temperatures is often attributed to temperature alone, whereas actually the differences may be due to the other variables which determine these temperatures.

Even careful investigators have obtained variant results as to the effect of temperature on groundwood pulping. Strauch (*1*) in an analysis of data published by Müller, Heller, May, and Schallock (*2*) shows that an increase in pit temperature lowers production (at a given power input), increases power consumption per ton, and increases the tensile strength of the pulp. The freeness was dependent upon both pit-temperature and the consistency. Enkel (*3*) on the other hand states that increased temperature leads to increased freeness and lower power consumption, with little if any effect on strength. Teicher (*4*) contends that high temperatures improve the quality without an increase in power consumption. In his work, the consistency was permitted to increase with the temperature.

The temperature variation across the face of a pulpstone causes a variation in the properties of the pulp, according to Drechsel (*5*). The pulp taken from the middle zone of the stone was hotter than that from zones near the edge and contained much more of the finer fiber and less of the coarser fiber. On the basis of theoretical considerations of friction-energy relationships, Schoengut (*6*) suggests that "thin-hot" grinding favors more uniform friction between the stone and the wood, giving more uniform pulp quality and a saving of energy. This has been substantiated by the work of Brecht (*7*), Malinowsky (*8*), and Brell (*9*). Mention of the effect of the temperature of grinding on the color of the pulp is seldom omitted from any discussion of the subject. Although it is generally believed that an excessively high temperature is detrimental to color, Sievers (*10*) observes that "pulp ground hot, if of a low freeness, is considerably whiter than if ground cold" and suggests that this may be due "to the light refraction caused by the wood particles being broken up more finely."

It is reasonable to suppose that temperature might have a marked influence on the grinding of wood. The wood itself is permanently affected by boiling in water for a period of time as evidenced by steaming and boiling processes sometimes used prior to grinding. Furthermore, wood becomes plastic at high temperatures, a fact made use of in the steam bending of wood. An additional factor is the change in viscosity of the water used as a grinding medium, with change in temperature.

The introduction of temperature controllers for grinders has stimulated interest in temperature as a grinding variable and has aided in its study. The Forest Products Laboratory initiated several years ago an investigation of the effect of temperature on grinding of which this article is a report of the results obtained thus far.

### Equipment

The experiments were made with a small two-pocket grinder carrying a stone 26 inches in diameter with an 11-inch face. Three pulpstones were used in this work, two composed of Aloxite abrasive and the third of natural sandstone from the Opekiske quarry. The pockets of the grinder are 8 inches in width and 11 inches in depth. The drive is a 75 hp. motor connected to the grinder by a V-belt. The power consumption is measured by means of a watt-hour meter and corrected for motor and transmission losses. Two commercial temperature controllers automatically regulate the grinding temperature and the shower water temperature, respectively. The thermal element of the instrument controlling the grinding temperature is located in front of the grinder stone and is sprayed with the pulp thrown off from the stone as it emerges from the pit. The shower water temperature controller allows the shower water to be maintained at any desired constant temperature above that of the supply. The shower water is admitted at the rear of the grinder through a perforated pipe oriented downward so as to project the water nearly tangent to but just missing the stone.

In connection with the shower water mention is made here of observations relative to the hardness of the water. In experiments listed in Table I of lower run number than 112, lake water (Lake Mendota) was used. The hardness (soap) of this water is about 185 parts per million. Nothing unusual as regards hardness was noted with this water. Grinder runs 112 to 118 inclusive were made with artesian well water (Madison city supply) which has a hardness of about 320 parts per million. In the latter series when the temperature of grinding exceeded 170 deg. F. the lime constituting the temporary hardness of the water was precipitated on the stone surface and so influenced results that these runs were discarded insofar as the study of the effect of temperature was concerned. The stone surface was then cleaned with acid and all subsequent experiments made with zeolite softened water in the pit showers.

### Wood Used and Its Preparation

Both spruce and loblolly pine were used in the grinding experiments. The spruce was obtained from logs 8 to 10 inches in diameter. The logs were cut into timbers with rectangular cross section measuring 6.5 inches on one side and of variable dimension in the other direction depending on the size of the log. These timbers were then sawed into blocks 9 inches long. Sections of about 1-inch thickness were also cut for moisture determinations. The 6.5-inch face of the block was always placed toward the stone surface which permitted a constant pressure of the wood against the stone. In order to obtain as nearly identical wood as possible for each of the several grinder runs constituting a series of experiments one block was taken from each of as many logs as were required for a given run, that is, if 10 blocks were required for a grinder run one block was taken from each of 10 logs. Each block was weighed separately and its dry wood content calculated from this weight and the moisture content of the log from which it came. The prepared wood was stored under conditions that allowed a negligible change in moisture content from run to run within a given series.

The loblolly pine wood was prepared similarly to the spruce except that the wood selected was from 5 to 6 inches in diameter and was not cut into rectangular shape but used in the form of round bolts, one bolt being ground at a time.

### Procedure

With the spruce from 50 to 75 pounds of wood (oven-dry basis) were ground for each experiment while with the loblolly pine about 35 pounds were used. Before making a grinder run the stone and grinder were uniformly heated for several hours with hot water to the desired

temperature. Immediately before the start of grinding, however, the temperature of the water in the pit was suddenly dropped about 20 degrees by introduction of cold water. Grinding was then commenced without the addition of shower water, whereupon the temperature rapidly rose as grinding proceeded until the original level was regained at which point the temperature control apparatus began to function by admitting shower water as demanded. By this time or soon thereafter the consistency of the pulp in the pit had risen to the normal for the temperature of the shower water employed.

In series in which both temperature and consistency were allowed to rise from run to run, the setting of the grinder temperature control instrument alone was changed. In series in which the grinding temperature was increased without major changes in consistency both the grinder temperature control and the shower temperature control were raised simultaneously. It might appear that a constant difference between the settings of the two instruments would give a constant consistency but owing to the fact that the higher the temperature of operation, the greater was the radiation of heat from the grinder, and that the wood charged was at approximately the same temperature in all runs it was found necessary to decrease the differential as the grinding temperature was increased in order to keep the consistency relatively constant. In a series where the consistency only was allowed to vary, the shower water temperature alone was systematically changed from run to run.

In all the spruce series except one, the variables of the last run of the series, that is, those variables which were under control, were made the same as those of the first run for the purpose of detecting changes in the stone surface; differences in results between the first and last runs being presumed to be due to this cause. In all series made with the Aloxite stones no effect could be attributed to change in stone surface. An effect considered as due to change of surface on the sand stone will be mentioned later.

In each series of runs in which the wood was duplicated the bolts from the several logs were ground in the same order in each run. After the stock in the pit had become thickened the pulp going over the dam was sampled from time to time for consistency determination. The pulp from the grinder was washed through a perforated plate or bull screen with holes one-half inch in diameter and then screened on a flat-plate diaphragm screen fitted with No.

TABLE I.—THE EFFECT OF TEMPERATURE AND CONSISTENCY IN THE GRINDING OF WHITE SPRUCE

| | Wood[1] | | Grinding conditions | | | | | | | | | Properties of pulp suspension | | | | | | | | Properties of pulp test sheets | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Temperature of | | | Yield per 100 pounds dry wood | | | Power | Freeness | | Screen analysis | | | | | | | | | Color analysis—Ives readings | | |
| | | | | | | | | | | | | | | Retained between— | | | | | | | | | | |
| Grinder run, No. | Shipment, No. | Dryness, Per cent | Service of stone since last burring, Hours | Pressure of wood on stone[2], Lbs./sq. in. | Shower water, Deg. F. | Grinding, Deg. F. | Consistency, Per cent | Screened pulp, Pounds | Screenings, Pounds | Dry wood ground per 24 hours[3], Tons | Input, Hp. | Per ton dry wood[3], Hp. days | Green, Cc. | Schopper-Riegler, Cc. | Retained on 24-mesh, Per cent | 24 and 42-mesh, Per cent | 42 and 80-mesh, Per cent | 80 and 150-mesh, Per cent | Passing 150-mesh, Per cent | Average screen opening[4], Mm. | Bursting per pound per ream[5] Points | Tearing per pound per ream[5] Grams | Tensile breaking length, Meters | Red, Parts | Green, Parts | Blue, Parts |
| Series 1.—Constant consistency, using an Aloxite stone (403 grit, grade F) burred with a 14-point diamond burr followed by a 10-cut spiral burr | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 57 | 1385 | 64 | 15.0 | 30 | 50 | 150 | 5.5 | 89 | 0.4 | 0.79 | 41 | 52 | 29 | ... | 3.8 | 1.5 | 15.5 | 20.5 | 58.7 | 0.075 | 0.24 | 0.47 | 2100 | 86 | 82 | 78 |
| 58 | 1385 | 64 | 16.2 | 30 | 69 | 165 | 5.8 | 91 | .5 | .86 | 42 | 49 | 30 | ... | 6.1 | 1.5 | 15.5 | 20.0 | 56.9 | .077 | .25 | .52 | 2070 | 87 | 82 | 76 |
| 59 | 1385 | 64 | 17.3 | 30 | 80 | 180 | 6.1 | 89 | .4 | .85 | 41 | 48 | 31 | ... | 6.0 | 4.1 | 15.7 | 19.6 | 54.6 | .079 | .27 | .49 | 2180 | 92 | 84 | 78 |
| 60 | 1385 | 64 | 18.4 | 30 | 104 | 195 | 6.3 | 90 | .5 | .90 | 41 | 46 | 32 | ... | 6.6 | 3.3 | 17.3 | 21.9 | 49.1 | .083 | .29 | .53 | 2360 | 92 | 85 | 77 |
| 61 | 1385 | 64 | 19.5 | 30 | 50 | 150 | 5.3 | 90 | .4 | .81 | 41 | 51 | 34 | ... | 1.5 | 2.5 | 15.6 | 25.4 | 55.0 | .076 | .25 | .42 | 2130 | 90 | 85 | 79 |
| Series 2.—Constant consistency, using an Aloxite stone (403 grit, grade F) burred with a 12-point diamond burr followed by an 8-cut spiral burr | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 84 | 1394 | 55 | 16.7 | 25 | 51 | 100 | 2.6 | 87 | 0.3 | 0.70 | 48 | 69 | 36 | 207 | 1.4 | 2.5 | 11.9 | 24.6 | 59.6 | 0.075 | 0.18 | 0.50 | 1950 | 89 | 78 | 75 |
| 85 | 1394 | 55 | 17.5 | 25 | 77 | 125 | 2.5 | 95 | .3 | .67 | 48 | 72 | 24 | 189 | 1.9 | 3.0 | 11.5 | 23.5 | 60.1 | .074 | .23 | .55 | 2400 | 86 | 79 | 74 |
| 86 | 1394 | 55 | 18.4 | 25 | 106 | 150 | 2.6 | 94 | .4 | .77 | 50 | 66 | 32 | 197 | 6.0 | 4.2 | 14.2 | 22.8 | 52.8 | .081 | .24 | .59 | 2210 | 86 | 78 | 74 |
| 87 | 1394 | 55 | 19.2 | 25 | 135 | 175 | 2.7 | 95 | .6 | .83 | 51 | 61 | 35 | 230 | 9.5 | 3.6 | 14.5 | 20.8 | 51.6 | .082 | .22 | .65 | 2060 | 86 | 77 | 74 |
| 88 | 1394 | 55 | 20.0 | 25 | 162 | 200 | 3.1 | 95 | .4 | .89 | 52 | 58 | 44 | 262 | 13.8 | 4.9 | 13.0 | 18.3 | 50.0 | .086 | .24 | .67 | 2020 | 86 | 79 | 73 |
| 89 | 1394 | 55 | 20.6 | 25 | 51 | 100 | 2.5 | 94 | .4 | .71 | 50 | 70 | 33 | 201 | 2.7 | 6.2 | 11.8 | 23.2 | 56.4 | .076 | .19 | .51 | 2120 | 88 | 78 | 74 |
| Series 3.—Constant consistency using an Opekiske sandstone burred with a 14-point diamond burr followed by an 8-cut spiral burr | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 90 | 1394 | 57 | 10.5 | 25 | 60 | 110 | 2.5 | 94 | 0.5 | 0.58 | 43 | 74 | 49 | 281 | 9.8 | 10.5 | 14.0 | 24.1 | 41.6 | 0.094 | 0.25 | 0.72 | 2320 | 84 | 77 | 71 |
| 91 | 1394 | 57 | 11.6 | 25 | 82 | 130 | 2.4 | 98 | .5 | .53 | 42 | 79 | 54 | 290 | 18.4 | 4.6 | 12.5 | 25.2 | 42.3 | .095 | .24 | .76 | 2100 | 84 | 77 | 71 |
| 92 | 1394 | 57 | 12.8 | 25 | 104 | 150 | 2.6 | 97 | .6 | .65 | 43 | 66 | 96 | 388 | 27.6 | 6.1 | 10.4 | 21.1 | 34.8 | .111 | .27 | .75 | 1940 | 85 | 77 | 72 |
| 93 | 1394 | 57 | 13.8 | 25 | 127 | 170 | 2.5 | .. | .5 | .59 | 44 | 75 | 77 | 347 | 25.8 | 4.8 | 10.0 | 20.3 | 39.1 | .103 | .27 | .73 | 1900 | 84 | 75 | 70 |
| 94 | 1394 | 57 | 14.9 | 25 | 151 | 190 | 2.4 | 96 | .6 | .60 | 44 | 74 | 80 | 360 | 30.5 | 5.7 | 9.4 | 17.9 | 36.5 | .107 | .30 | .87 | 2240 | 85 | 76 | 72 |
| 95 | 1394 | 57 | 15.9 | 25 | 60 | 110 | 2.1 | 99 | .5 | .50 | 41 | 80 | 59 | 312 | 11.2 | 6.9 | 10.4 | 24.9 | 46.6 | .088 | .25 | .58 | 2010 | 86 | 74 | 70 |
| Series 4.—Constant consistency, using an Aloxite stone (406 grit, grade K) burred with a 10-cut spiral burr | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 112 | 1423 | 71 | 24.0 | 27 | 45 | 110 | 4.3 | 91 | 0.4 | 1.01 | 51 | 51 | 65 | 318 | 1.3 | 3.6 | 12.9 | 24.5 | 58.7 | 0.074 | 0.11 | 0.33 | 1180 | 81 | 75 | 66 |
| 113 | 1423 | 71 | 24.5 | 27 | 68 | 130 | 4.3 | 92 | .4 | 1.00 | 49 | 49 | 70 | 328 | 2.3 | 3.7 | 16.2 | 25.2 | 52.6 | .079 | .16 | .37 | 1450 | 82 | 74 | 66 |
| 114 | 1423 | 71 | 25.1 | 27 | 91 | 150 | 4.3 | 91 | .4 | 1.08 | 51 | 47 | 91 | 355 | 5.1 | 6.9 | 15.7 | 24.3 | 48.0 | .085 | .16 | .40 | 1620 | 83 | 75 | 67 |
| 115 | 1423 | 71 | 25.6 | 27 | 113 | 170 | 4.8 | 94 | .5 | 1.11 | 51 | 46 | 122 | 397 | 10.0 | 6.5 | 17.3 | 22.4 | 43.8 | .092 | .16 | .43 | 1440 | 82 | 74 | 65 |
| 119 | 1423 | 71 | 28.8 | 27 | 141 | 190 | 5.0 | 96 | .8 | 1.15 | 49 | 43 | 124 | 415 | 10.3 | 5.8 | 17.3 | 21.9 | 44.7 | .091 | .16 | .52 | 1500 | 80 | 73 | 63 |
| Series 5.—Consistency allowed to vary with temperature, using same stone and burr pattern as in series 3 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 96 | 1394 | 62 | 17.2 | 25 | 70 | 110 | 1.6 | 96 | 0.4 | 0.47 | 43 | 93 | 27 | 246 | 5.6 | 10.8 | 12.9 | 23.4 | 47.3 | 0.087 | 0.28 | 0.68 | 2320 | 85 | 76 | 70 |
| 97 | 1394 | 62 | 18.6 | 25 | 70 | 130 | 2.3 | 98 | .5 | .47 | 43 | 92 | 30 | 246 | 10.7 | 7.9 | 10.5 | 25.7 | 45.2 | .089 | .28 | .67 | 2420 | 84 | 76 | 72 |
| 98 | 1394 | 62 | 20.0 | 25 | 70 | 150 | 3.1 | 97 | .4 | .45 | 44 | 99 | 30 | 256 | 13.4 | 7.9 | 10.4 | 24.8 | 43.5 | .092 | .31 | .74 | 2380 | 84 | 76 | 70 |
| 99 | 1394 | 62 | 21.5 | 25 | 70 | 170 | 4.0 | 93 | .5 | .49 | 45 | 92 | 43 | 283 | 21.8 | 7.3 | 9.2 | 22.7 | 39.0 | .101 | .31 | .78 | 2490 | 84 | 75 | 69 |
| 100 | 1394 | 62 | 22.9 | 25 | 70 | 190 | 4.8 | 92 | .6 | .40 | 40 | 100 | 56 | 308 | 20.8 | 6.4 | 10.4 | 21.0 | 41.4 | .098 | .29 | .70 | 2080 | 86 | 76 | 71 |
| 101 | 1394 | 62 | 24.5 | 25 | 70 | 110 | 1.6 | 94 | .5 | .43 | 43 | 91 | 35 | 260 | 10.7 | 7.4 | 11.9 | 26.5 | 43.5 | .091 | .29 | .63 | 2300 | 84 | 76 | 71 |
| Series 6.—Consistency variable, temperature constant, using stone surface as in series 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | 1385 | 75 | 20.7 | 30 | 130 | 165 | 2.3 | 92 | 0.7 | 0.99 | 42 | 42 | 29 | ... | 2.4 | 2.3 | 16.5 | 25.7 | 53.1 | 0.078 | 0.23 | 0.47 | 2240 | 87 | 76 | 71 |
| 63 | 1385 | 75 | 21.7 | 30 | 100 | 165 | 4.3 | 93 | .6 | .98 | 42 | 43 | 29 | ... | 2.5 | 3.0 | 15.3 | 24.2 | 55.0 | .077 | .24 | .48 | 2330 | 85 | 77 | 70 |
| 64 | 1385 | 75 | 22.7 | 30 | 70 | 165 | 5.3 | 93 | .7 | .89 | 42 | 48 | 25 | ... | 2.2 | 2.9 | 13.9 | 24.0 | 57.0 | .075 | .23 | .51 | 2380 | 86 | 78 | 73 |
| 65 | 1385 | 75 | 23.8 | 30 | 47 | 165 | 6.0 | 90 | .7 | .79 | 41 | 52 | 25 | ... | 3.3 | 2.9 | 15.5 | 24.8 | 54.5 | .078 | .26 | .51 | 2220 | 86 | 78 | 73 |
| 66 | 1385 | 75 | 25.1 | 30 | 130 | 165 | 2.1 | 89 | .7 | 1.00 | 40 | 40 | 35 | ... | 2.3 | 3.4 | 15.4 | 25.4 | 53.5 | .078 | .22 | .48 | 2120 | 85 | 79 | 73 |

[1] All wood was in the form of rectangular bolts 6.5 inches wide. The bolts were 9 inches in length.
[2] Calculated from the actual thrust delivered to the pressure foot as determined by calibration.
[3] Power and production data are expressed on basis of wood ground instead of pulp produced since the latter figures are somewhat inaccurate.
[4] This value, calculated from the screen analysis and the sizes of the screen openings, is a function of the average fiber length of the pulp.
[5] Based on a 25x40—500 ream.

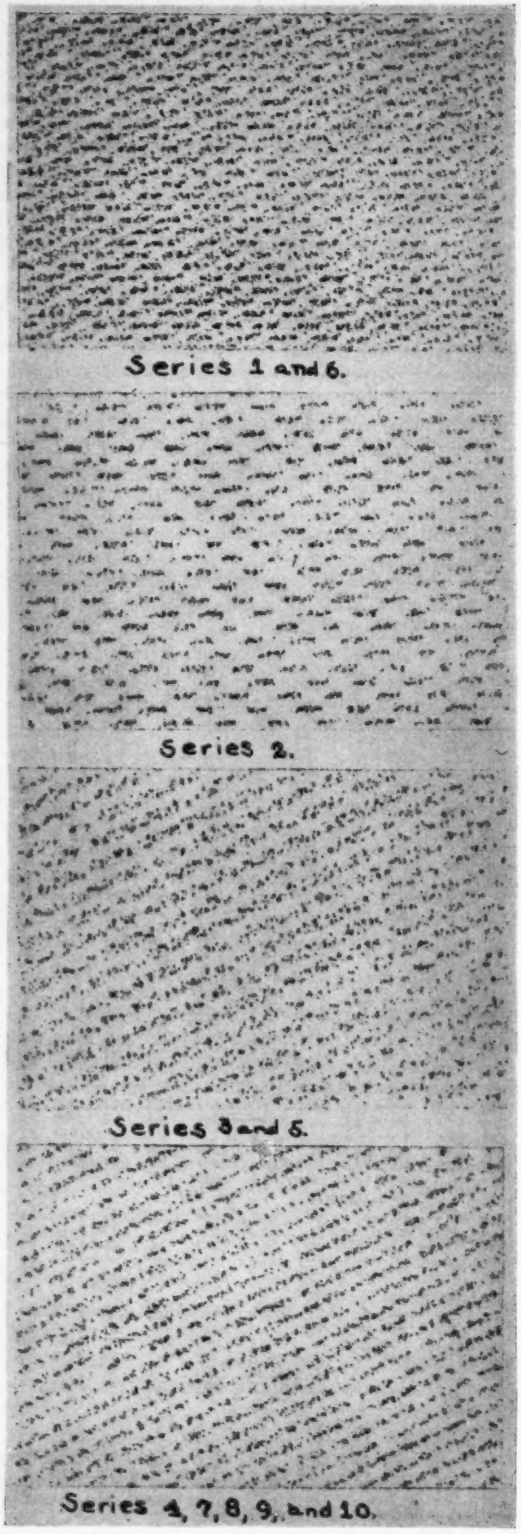


PLATE 1.—CARBON PAPER IMPRESSIONS OF THE GRINDER STONE SURFACES.

Series 1 and 6.—Aloxite stone (403-grit, grade F) burred with a 14-point diamond burr followed by a 10-cut spiral burr.

Series 2.—Aloxite stone (403-grit, grade F) burred with a 12-point diamond burr followed by an 8-cut spiral burr.

Series 3 and 5.—Opekiske sandstone burred with a 14-point diamond burr followed by an 8-cut spiral burr.

Series, 4, 7, 8, 9 and 10.—Aloxite stone (403-grit, grade K) burred with a 10-cut spiral burr.

SEE OPPOSITE COLUMN FOR LEGEND.

TAPPI SECTION, PAGE 170

12 plates. From the screen the pulp passed over a small wet machine where the dewatered pulp was sampled at frequent intervals. Two samples were taken, one for a determination of the moisture content and the other for pulp quality. The sample for moisture content was used in the determination of the yield of pulp on the oven-dry basis and, therefore, was taken throughout the entire run. The sample for quality determination was taken during about the last two-thirds of the run.

The pulps were tested according to the standard Forest Products Laboratory methods (*12*).

### Discussion of Results

Plate I shows carbon paper impressions of the various grinder stone surfaces used. The data obtained on the grinding of spruce are shown in Table I and that obtained with loblolly pine in Table II. The principal data are shown in chart form in Figs. 1, 2, and 3.

The effect of an increase in grinding temperature at constant consistency as shown in Fig. 1, series 1, was a tendency to increase the grinding rate with a slight decrease in power consumption. A marked increase in fiber length and bursting strength also took place while tensile and tearing strengths had a tendency toward slight improvement. In series 2 the temperature range was extended and a different burr pattern used. In this series as in the first the increase in grinding rate was slight but the decrease in power consumption was considerable with rise in temperature. An increase in average fiber length as indicated by the average screen opening (see Table I) occurred, but the change in fiber length was most noticeable in the coarsest fiber fraction. The bursting strength did not show any definite trend. The tearing strength increased with temperature but the tensile strength decreased. In this series and in subsequent temperature series made at constant consistency, the runs made at the lowest temperature did not, in general, fit in with the trend shown by the rest of the runs.

The data obtained with an Opekiske sandstone are erratic, as shown in Fig. 1, possibly due to slight wear of the stone from run to run. Comparing the first and last run of the series (Table I) the power consumption and production as well as one or two of the pulp test results indicate this wearing of the stone surface. The bursting strengths, however, show a tendency to increase with temperature.

In an attempt to obtain longer fibered pulp from an artificial stone, a coarser grained Aloxite stone was used in series 4 than in series 1 and 2. However, only a slight improvement in fiber length was obtained and the other results were similar to those obtained in series 2.

In series 5 the wood was ground on the same stone surface as in series 3 but the consistency of the pulp was allowed to increase with the grinding temperature. As in series 3 the results were erratic but it should be noted that the highest temperature run in series 3 (No. 94) at a consistency of 2.4 per cent had better strength than those at the lower temperatures while in series 5 the strength had a tendency to decrease as the temperature was increased above 150 deg. F. This may be attributed to a counter effect caused by the rise in consistency in series 5.

In the grinding of loblolly pine (series 7, 8, 9 and 10, Table II and Fig. 2) it was found that a slightly higher

grinding rate, a distinct increase in fiber length, and an increase in bursting and tearing strength were obtained at the higher temperatures. The power consumption was also lowered. Although for the most part these effects took place whether the consistency was allowed to increase or not with the temperature a very slight advantage of a moderate consistency (4 to 5 per cent) seemed apparent. The effect of wood variables on the pulping properties of the southern pines is a current problem which will be reported later. However, it may be noted in Fig. 2 that slightly better results were obtained from pine containing the higher volume of springwood.

In series 6 a study was made of the effect of varying the consistency at a constant grinding temperature. The results obtained (see Fig. 3) were a decrease in grinding rate and an increase in power consumption when the consistency rose much above 4 per cent. The properties of the pulp were changed but little.

In addition to the effects charted in figs. 1, 2, and 3, the data in Tables I and II indicate that pulps of higher freeness are generally obtained at the higher grinding temperatures.

The detrimental effect of high temperature on the color of the pulp so frequently observed, may undoubtedly be attributed to the fact that high temperature in the normal operation of a grinder is usually accompanied by high consistency. When the consistency becomes so high that the pulp is not washed from the stone and the latter is not cooled below the scorching point of the wood, discoloration of the pulp occurs. These experiments indicate that if the consistency is maintained well below this point, the color of the pulp is not materially affected by the grinding temperature.

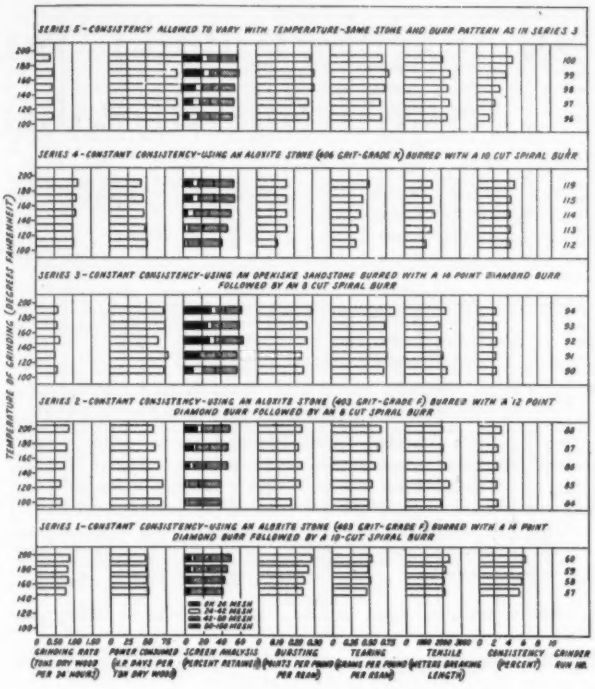
SERIES 5-CONSISTENCY ALLOWED TO VARY WITH TEMPERATURE-SAME STONE AND BURR PATTERN AS IN SERIES 3
SERIES 4-CONSTANT CONSISTENCY-USING AN ALOXITE STONE (406 GRIT-GRADE K) BURRED WITH A 10 CUT SPIRAL BURR
SERIES 3-CONSTANT CONSISTENCY-USING AN OPEKISKE SANDSTONE BURRED WITH A 14 POINT DIAMOND BURR FOLLOWED BY AN 8 CUT SPIRAL BURR
SERIES 2-CONSTANT CONSISTENCY-USING AN ALOXITE STONE (403 GRIT-GRADE F) BURRED WITH A 12 POINT DIAMOND BURR FOLLOWED BY AN 8 CUT SPIRAL BURR
SERIES 1-CONSTANT CONSISTENCY-USING AN ALBSITE STONE (403 GRIT-GRADE F) BURRED WITH A 14 POINT DIAMOND BURR FOLLOWED BY A 10-CUT SPIRAL BURR
TEMPERATURE OF GRINDING (DEGREES FAHRENHEIT)
GRINDING RATE (TONS DRY WOOD PER 24 HOURS)
POWER CONSUMED (H.P. DAYS PER TON DRY WOOD)
SCREEN ANALYSIS (PERCENT RETAINED)
BURSTING (POINTS PER POUND PER REAM)
TEARING (GRAMS PER POUND PER REAM)
TENSILE (METERS BREAKING LENGTH)
CONSISTENCY (PERCENT)
GRINDER RUN NO.

FIG. 1.
**The effect of temperature and consistency in the grinding of white spruce.**

### Conclusions and Future Work

The preliminary results of this investigation indicate that in commercial practice appreciable benefit might be derived by raising the grinding temperature above that now commonly employed. To accomplish this without obtaining high consistencies and without supplying additional heat necessitates the conservation of the heat produced by grinding. This undoubtedly could be accomplished by lagging the stock lines, the white water return pipes, and

TABLE II.—THE EFFECT OF TEMPERATURE AND CONSISTENCY IN THE GRINDING OF LOBLOLLY PINE

| | Grinding conditions[3] | | | | | | | | | Properties of pulp suspension | | | | | | | Properties of pulp test sheets | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wood[1] | | | Temperature of | | Yield per 100 pounds dry wood | | | Power | | Screen analysis | | | | | | | | | | Color analysis—Ives readings | | |
| | | | | | | | | | | | Retained between | | | | | | | | | | | | |
| Grinder run, No. | Volume of spring-wood, Per cent | Dryness, Per cent | Service of stone since last burring, Hours | Shower water, Deg. F. | Grinding, Deg. F. | Consistency, Per cent | Screened pulp, Pounds | Screenings, Pounds | Dry wood ground per 24 hours[2], Tons | Input, Hp. | Per ton dry wood[3], Hp. days | Freeness Schopper-Riegler, Cc. | Retained on 24-mesh, Per cent | 24 and 42-mesh, Per cent | 42 and 80-mesh, Per cent | 80 and 150-mesh, Per cent | Passing 150-mesh, Per cent | Average screen opening[4], Mm. | Bursting per pound per ream[5], Points | Tearing per pound per ream[5], Grams | Tensile per sq. in., Pounds | Red, Parts | Green, Parts | Blue, Parts |
| Series 7.—Medium springwood, constant consistency, using an Aloxite stone (406 grit, grade K) burred with a 10-cut spiral burr | | | | | | | | | | | | | | | | | | | | | | | | |
| 151 | 61 | 50 | 140.0 | 60 | 130 | 3.7 | 89 | 0.3 | 0.51 | 33 | 64 | 277 | 1.8 | 5.4 | 14.7 | 17.8 | 60.3 | 0.074 | 0.13 | 0.53 | 933 | 83 | 74 | 65 |
| 152 | 61 | 50 | 140.7 | 101 | 160 | 4.0 | 86 | .3 | .60 | 37 | 61 | 325 | 5.4 | 8.1 | 17.8 | 15.7 | 52.6 | .082 | .15 | .50 | 855 | 82 | 72 | 65 |
| 153 | 61 | 50 | 141.5 | 150 | 190 | 4.4 | 90 | .4 | .60 | 32 | 53 | 348 | 7.7 | 12.2 | 15.2 | 15.6 | 49.3 | .087 | .19 | .46 | 1060 | 83 | 73 | 65 |
| Series 8.—High springwood, constant consistency, using same stone and burr pattern as in series 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 154 | 71 | 41 | 142.2 | 60 | 130 | 3.9 | 94 | 0.3 | 0.51 | 38 | 73 | 293 | 1.2 | 3.7 | 15.3 | 23.7 | 56.1 | 0.075 | 0.15 | 0.50 | 1152 | 82 | 72 | 65 |
| 155 | 71 | 41 | 142.9 | 106 | 160 | 3.9 | 91 | .3 | .53 | 36 | 66 | 307 | 2.4 | 7.1 | 17.2 | 20.9 | 52.4 | .080 | .16 | .58 | 1070 | 81 | 74 | 65 |
| 156 | 71 | 41 | 143.5 | 155 | 190 | 3.7 | 92 | .4 | .60 | 35 | 57 | 330 | 5.1 | 10.9 | 17.6 | 19.1 | 47.3 | .089 | .20 | .65 | 1227 | 81 | 72 | 65 |
| Series 9.—Medium springwood, consistency allowed to vary with temperature, using same stone and burr pattern as in series 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 157 | 58 | 49 | 144.3 | 98 | 130 | 2.2 | 89 | 0.3 | 0.54 | 35 | 63 | 302 | 2.5 | 6.9 | 13.3 | 20.6 | 56.7 | 0.077 | 0.11 | 0.41 | 840 | 80 | 72 | 66 |
| 158 | 58 | 49 | 145.0 | 98 | 160 | 3.9 | 88 | .3 | .53 | 33 | 61 | 278 | 3.3 | 10.1 | 14.4 | 20.4 | 51.8 | .082 | .14 | .51 | 862 | 80 | 73 | 66 |
| 159 | 58 | 49 | 145.9 | 100 | 190 | 6.4 | 89 | .3 | .57 | 34 | 59 | 313 | 8.6 | 12.2 | 14.7 | 17.8 | 46.7 | .088 | .15 | .62 | 760 | 81 | 74 | 66 |
| Series 10.—High springwood, consistency allowed to vary with temperature, using same stone and burr pattern as in series 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 160 | 73 | 40 | 146.5 | 104 | 130 | 1.7 | 91 | 0.3 | 0.50 | 37 | 74 | 252 | 0.9 | 6.2 | 15.7 | 15.6 | 61.6 | 0.073 | 0.14 | 0.46 | 1094 | 81 | 73 | 66 |
| 161 | 73 | 40 | 147.2 | 103 | 160 | 3.9 | 91 | .3 | .59 | 36 | 59 | 303 | 1.4 | 8.6 | 16.9 | 20.0 | 53.1 | .080 | .14 | .43 | 998 | 80 | 74 | 66 |
| 162 | 73 | 40 | 147.9 | 104 | 190 | 5.4 | 93 | .4 | .58 | 32 | 56 | 283 | 5.0 | 13.0 | 16.4 | 19.8 | 45.8 | .089 | .18 | .56 | 1024 | 81 | 73 | 65 |

[1] Shipment 1425.
[2] The pressure of the wood against the stone was 21 pounds per square inch based on the actual thrust delivered by the pressure foot and the area represented by the product of the average diameter of the wood bolts and their length.
[3] Power and production data are expressed on basis of wood ground instead of pulp produced since the latter figures are somewhat inaccurate.
[4] This value, calculated from the screen analysis and the sizes of the screen openings, is a function of the average fiber length of the pulp.
[5] Based on a 25x40—500 ream.

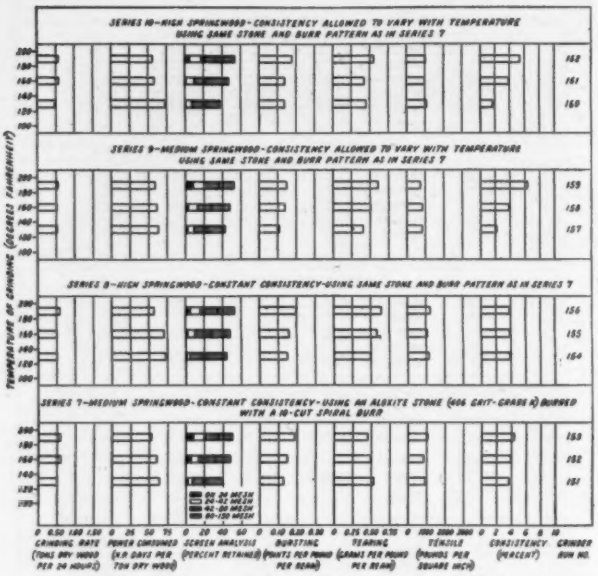
SERIES 10—HIGH SPRINGWOOD-CONSISTENCY ALLOWED TO VARY WITH TEMPERATURE USING SAME STONE AND BURR PATTERN AS IN SERIES 7
SERIES 9—MEDIUM SPRINGWOOD-CONSISTENCY ALLOWED TO VARY WITH TEMPERATURE USING SAME STONE AND BURR PATTERN AS IN SERIES 7
SERIES 8—HIGH SPRINGWOOD-CONSTANT CONSISTENCY-USING SAME STONE AND BURR PATTERN AS IN SERIES 7
SERIES 7—MEDIUM SPRINGWOOD-CONSTANT CONSISTENCY-USING 46 ALOXITE STONE (406 GRIT-GRADE H) BURRED WITH A 10-CUT SPIRAL BURR
TEMPERATURE OF GRINDING (DEGREES FAHRENHEIT)
ON 24 MESH
24-42 MESH
42-80 MESH
80-150 MESH
GRINDING RATE (TONS DRY WOOD PER 24 HOURS)
POWER CONSUMED (H.P. DAYS PER TON DRY WOOD)
SCREEN ANALYSIS (PERCENT RETAINED)
BURSTING (POINTS PER POUND PER REAM)
TEARING (GRAMS PER POUND PER REAM)
TENSILE (POUNDS PER SQUARE INCH)
CONSISTENCY (PERCENT)
GRINDER RUN NO.

FIG. 2.
**The effect of temperature and consistency in the grinding of loblolly pine.**

possibly even the grinder and by the use of as much white water in the pit showers as possible.

On account of the limited peripheral contact of wood against stone in the small grinder the results obtained thus far may not be directly comparable with commercial practice. It is, therefore, planned to repeat portions of this work in a new experimental grinder having a peripheral contact equal to that of many commercial machines *(11)*. It is generally believed that the warming of the wood by the steam rising in the grinder pocket helps to produce a longer fibered pulp. Since it is evident that the heat utilized in this way can do little but warm the outside of the sticks of wood it is of interest to determine the effect of preheating the sticks all through to a temperature close to that of grinding. Such a study is contemplated.

Other questions related to the effect of temperature in the grinding process require an answer. For instance, what is the actual temperature at the stone-wood contact and does this heat, as suggested by Schoengut (*6*), vaporize the moisture in the wood cells and, by the pressure thus developed, cause the fiber to become ruptured when removed from the wood by the grindstone? Another question of interest is whether it is the increase in temperature or the decrease in viscosity of the water, with consequent change in friction, that causes the apparent improvement in operation and pulp quality. More information on such factors as these would undoubtedly lead to improvements in the groundwood process.

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## Improved TAPPI Method for Testing Water Resistance of Paper

Improved technic in testing the water resistance of paper and paperboards has been incorporated in a revision of the official method of TAPPI. The principle of the official method was based on the dry-indicator test developed by F. T. Carson at the National Bureau of Standards. This consists in bringing one side of the test specimen in contact with water and finding the time required for the water to pass through the specimen as indicated by the development of color in an indicator powder consisting of a mixture of water-soluble dye and sugar. Improved devices for testing both paper and paper-boards in a more convenient and accurate manner were developed by Carson and by P. W. Codwise. Carson described new means of floating the test specimens on the water in PAPER TRADE JOURNAL, October 20, 1932 and May 24, 1934; and Codwise, in the same journal, March 8, 1934, described the application of the water from a cylinder placed on the specimens, with observation of the lower surface of the paper by means of an inclined mirror. These, together with other modifications developed through trial testing by members of a subcommittee under the direction of Codwise, have extended the scope of the method and rendered it preeminently suitable for the wide variety of paper products having water resistance as an important use requirement.

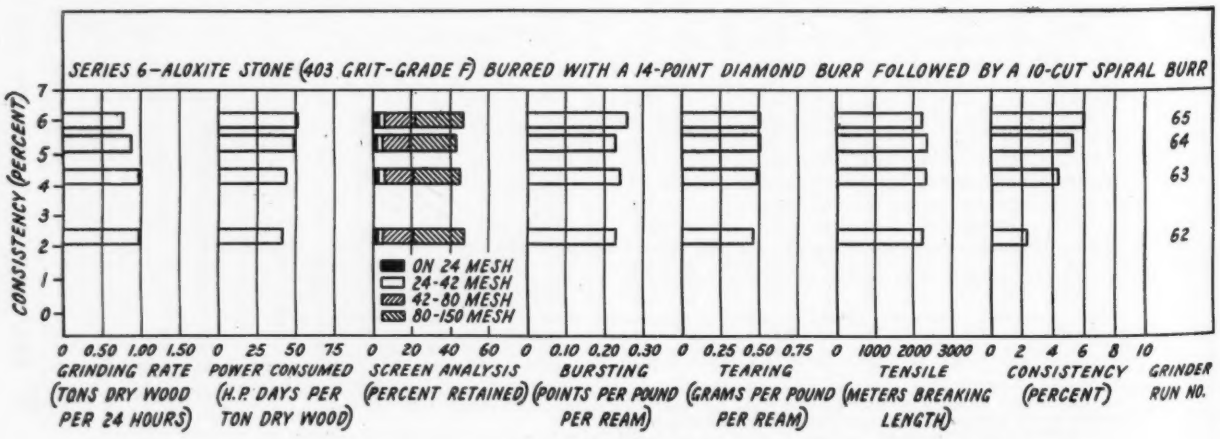
SERIES 6—ALOXITE STONE (403 GRIT-GRADE F) BURRED WITH A 14-POINT DIAMOND BURR FOLLOWED BY A 10-CUT SPIRAL BURR
CONSISTENCY (PERCENT)
ON 24 MESH
24-42 MESH
42-80 MESH
80-150 MESH
GRINDING RATE (TONS DRY WOOD PER 24 HOURS)
POWER CONSUMED (H.P. DAYS PER TON DRY WOOD)
SCREEN ANALYSIS (PERCENT RETAINED)
BURSTING (POINTS PER POUND PER REAM)
TEARING (GRAMS PER POUND PER REAM)
TENSILE (METERS BREAKING LENGTH)
CONSISTENCY (PERCENT)
GRINDER RUN NO.

FIG. 3.
**The effect of consistency on grinding of white spruce at a temperature of 165 deg. F.**

# Hourly Wage Rates and Their Relation to Minimum Hourly Rates in the Paper and Pulp Industry*

By John P. Hagenauer[1]

**Abstract**

*An outline of the various wage rate theories with consideration given to their advantages and defects. Tables showing wage rates for occupations in the paper industry are shown. These show the ratios existing between occupational rates and minimum rates.*

Ever since the development of modern industry, economists have advanced various theories of wages. None has been universally accepted. Some have been disproved by experience and have been discarded.

However, any or all of them contain one or more of the factors and forces affecting variations in wage levels and disclose limits between which wages must lie.

The oldest, namely *The Cost of Subsistence Theory* was formulated during the worst period of industrial revolution and is the most ruthless, and now completely discarded. It held that the wage level is determined by maintaining a working force at the point of bare subsistence. It ignored labor unions, productivity, and the fact that labor has a demand as well as a supply price. It showed clearly, however, the level below which wages cannot go or remain.

The other limit of wages is clearly defined by the so-called *Specific Productivity Theory.* Even this fails to give a full explanation of all phenomena of wages. Final utility, or in other words, service rendered by the employee to the enterprise determines the price of labor. Wages are paid out of production and cannot permanently remain above the point where profit ceases. If wages are above this point, employers will cease to use labor or must ultimately fail. This sets a definite upper limit of wages. The theory assumes absolute freedom of competition and the possibility of exact labor value measurements. The latter, however, is accomplished with difficulty, only in a few of the best managed plants, and certainly is not possible in the industry at large.

The *Wage Fund Theory* holds that wage levels depend upon supply and demand, or, in other words, upon the ratio of number of workers to capital expended in purchase of labor. This theory, while partly correct, ignores utility and influence of labor unions and fails to account for the difference in wage levels between trades. Production, not capital funds, pays for wages.

That the wage earner is the residual claimant of what is left after the payment of taxes, rent, interest and profits, which are determined by definite economic laws, is the claim of the *Residual Claimant Theory.* In practice, the enterprise or proprietor's share is more truly residual.

*The Bargaining Theory* is practical, but assumes equality of bargaining power and does not explain the existing reasonably definite wage levels in unorganized industries. It considers the standard of living, labor conditions, etc., but fails to make allowance for the effect on the public or, better, the consumer.

**Basis of Wage Rates**

From the above most prominent theories, and others, too numerous to mention, the following can be deduced:

1. Wages are paid out of production.
2. Wages are the result of a three-cornered competition between capital, labor and the consumer.
3. The relative strength of these three factors is based mainly upon the law of supply and demand and upon their respective bargaining powers.
4. Wage levels cannot permanently be in excess of productivity of labor nor below the minimum requirements of standards of living of any wage-earner group concerned.
5. Between the above limits the wages of a given group will depend upon the following:
   (a) Supply and demand.
   (b) Amount of profit and competitive condition in the industry groups.
   (c) Organization and relative bargaining power of employers and employees.
   (d) Productivity of labor.
   (e) Cost of living and purchasing power of money in the community.
   (f) Type of community in which plant is located.
   (g) Competitive wages in same community.
   (h) Mobility of labor.
   (i) Knowledge of labor market.
   (j) Custom or tradition.
   (k) Possibility of and ease with which the replacement of labor can be made, by improved machinery or process.

The wage problem has two distinct elements:

1. What constitutes a day's work.
2. What price shall be paid for such a day's work.

The first covers a clear determination of what quantity and quality of work an employee shall furnish in a given occupation and what conditions, equipment, and material the employer should supply.

The price or wage paid for this pre-determined quality of work depends upon numerous factors characteristic of each particular occupation. Some of the factors usually encountered follow:

(a) Physical effort required.
(b) Personal skill necessary (not based on training).
(c) Hazards involved.
(d) Strain due to speed, noise, tension, etc.
(e) Disagreeableness of working conditions.
(f) Possibilities of advancement.
(g) General education required.
(h) Special instruction and training.
(i) Experience required and length of service.
(j) Steadiness of employment.
(k) Labor supply of particular occupation and in general.

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* Presented by title at the fall meeting of the Technical Association of the Pulp and Paper Industry, Ambassador Hotel, Atlantic City, N. J., Sept. 18-21, 1935.

[1] Member TAPPI, American Paper and Pulp Association, New York, N. Y.

(l) Cost of living.
(m) Wages in community.
(n) Wages in industry.
(o) Financial situation of industry, whether profitable or sharply competitive.

Not all of these factors are usually present, but any or all of them may be found. Usually, if recognized or not, there exists in a given community or region a base wage applicable to general unskilled labor, influenced and fixed by factors (l) to (o), inclusive. This base rate is that fundamental rate at which the unskilled and less efficient employee can be profitably employed. It is governed by the minimum cost of living in the community for an average size family. All other rates above this minimum should be recognized by a ratio to the base rate determined for each occupation with due consideration of the influence of factors (a) to (k).

These individual occupational rates must be set with due consideration of current wage rates in the community and rates paid in the same establishment for all other kinds of work, which in the mind of employees might be compared for similarly. Rates should be equalized. This does not mean that rates should be identical, but that the ratios between remuneration and difficulties of occupations should be equalized.

### Technological Unemployment

Before leaving the general subject, it might be well to discuss the much raised question, "What has been the effect of technological development on wages?" Unquestionably, it has helped to increase the hourly rates, but, on the other hand, it has drawn more sharply the line of demarcation between unskilled and skilled labor and has created a class of employees highly specialized in certain specific occupations. This group, somewhat raised above unskilled labor, receives a higher hourly rate.

A good example in the paper industry is furnished in the boiler house. Before the advent of mechanical firing, three distinct classes of employees could be observed in this department: Unskilled men, wheeling coal and ashes; semi-skilled, but trained ones, attending to the actual firing, and skilled operators, the head firemen, supervising. Today, where mechanical firing is used, we still find the coal and ash handlers and the head firemen, while the actual firemen have disappeared. They have either been reduced to coal and ash handlers and thereby been absorbed by the unskilled class, or have been transferred to other mill departments into unskilled operations.

The wages of the unskilled employees have remained at the former lower level or been slightly increased in accordance with the general wage trend, while those of the head firemen have noticeably risen since their new duties require high mechanical skill.

In 1921, *Management Engineering* published a study on *setting of time rates.* Two of the tables published in this article, with slight alteration, have been used and made applicable to the industry. The ratios given in Tables I and II may not be absolutely correct in every instance or applicable to every mill, but it is interesting to study their application in general to the occupational rates as supplied by the industry's mills in a special survey made by the Paper Industry Authority in September, 1934.

From thousands of studies, engineers have established certain percentages to be added to base rates for the various factors influencing occupational hourly rates. Table I shows the effect of these percentages as ratios of occupational hourly rates and the actual rates on the basis of a 40c minimum hourly rate. This table is applicable to all occupations.

### Paper Mill Occupational Rates

Experience, however, has shown that the rates found on this basis are not sufficiently high under certain conditions. In the case of operators of modern highly specialized machinery, with its high speeds, high production, and therefore, high repair costs, it is of interest to the manufacturer to have operators, who, through their skill, can and do maintain production on these machines at a maximum, with a minimum of shutdowns. To accomplish this purpose, and as an inducement to the operator, it has been found necessary and advisable to increase the hourly rates of pay in proportion to the machine repair charges per operating hour.

No comparative data is available for our industry in regard to these hourly machine repair charges. Therefore Tables II and III are based on estimated charges from over $1.50 to over $5.00 per machine hour.

To illustrate the application of these ratios, let us analyze an occupation common to all mills, that of machine tender. On him rests the responsibility for output and

TABLE NO. I

| | Factors To Be Considered When Classifying Occupations | Ratios of Occupational Rates to Minimum Rate — Machine Charges Not Considered — Skill Class | | | | | | | Hourly Wage Rates on Basis of 40 Cents Minimum Rate — Skill Class | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional |
| 1 | Speed | 100 | 100 | 100 | 104 | 106 | 108 | 110 | 0.400 | 0.400 | 0.400 | 0.416 | 0.424 | 0.432 | 0.440 |
| 2 | Strength | 100 | 104 | 106 | 108 | 112 | 116 | 120 | 0.400 | 0.416 | 0.424 | 0.432 | 0.448 | 0.464 | 0.480 |
| 3 | Men Hard to Get | 100 | 100 | 100 | 110 | 115 | 120 | 130 | 0.400 | 0.400 | 0.400 | 0.440 | 0.460 | 0.480 | 0.520 |
| 4 | Strength and Speed | 100 | 104 | 106 | 112 | 118 | 124 | 130 | 0.400 | 0.416 | 0.424 | 0.448 | 0.472 | 0.496 | 0.520 |
| 5 | Working Conditions Disagreeable and Hazardous | 100 | 100 | 100 | 110 | 120 | 130 | 140 | 0.400 | 0.400 | 0.400 | 0.440 | 0.480 | 0.520 | 0.560 |
| 6 | Skill | 100 | 104 | 106 | 110 | 120 | 130 | 140 | 0.400 | 0.416 | 0.424 | 0.440 | 0.480 | 0.520 | 0.560 |
| 7 | Speed and Working Conditions Disagreeable and Hazardous | 100 | 100 | 100 | 114 | 126 | 138 | 150 | 0.400 | 0.400 | 0.400 | 0.456 | 0.504 | 0.552 | 0.600 |
| 8 | Skill and Speed | 100 | 104 | 106 | 114 | 126 | 138 | 150 | 0.400 | 0.416 | 0.424 | 0.456 | 0.504 | 0.552 | 0.600 |
| 9 | Skill and Strength | 100 | 108 | 112 | 118 | 132 | 146 | 160 | 0.400 | 0.432 | 0.448 | 0.472 | 0.528 | 0.584 | 0.640 |
| 10 | Working Conditions Disagreeable and Hazardous and Men Hard to Get | 100 | 100 | 100 | 120 | 135 | 150 | 170 | 0.400 | 0.400 | 0.400 | 0.480 | 0.540 | 0.600 | 0.680 |
| 11 | Skill and Men Hard to Get | 100 | 104 | 106 | 120 | 135 | 150 | 170 | 0.400 | 0.416 | 0.424 | 0.480 | 0.540 | 0.600 | 0.680 |
| 12 | Strength, Speed and Working Conditions Disagreeable and Hazardous | 100 | 104 | 106 | 122 | 138 | 154 | 170 | 0.400 | 0.416 | 0.424 | 0.488 | 0.552 | 0.616 | 0.680 |
| 13 | Skill, Strength and Speed | 100 | 108 | 112 | 122 | 138 | 154 | 170 | 0.400 | 0.432 | 0.448 | 0.488 | 0.552 | 0.616 | 0.680 |
| 14 | Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 100 | 100 | 100 | 124 | 141 | 158 | 180 | 0.400 | 0.400 | 0.400 | 0.496 | 0.564 | 0.632 | 0.720 |
| 15 | Skill and Working Conditions Disagreeable and Hazardous | 100 | 104 | 106 | 120 | 140 | 160 | 180 | 0.400 | 0.416 | 0.424 | 0.480 | 0.560 | 0.640 | 0.720 |
| 16 | Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 100 | 104 | 106 | 132 | 153 | 174 | 200 | 0.400 | 0.416 | 0.424 | 0.528 | 0.612 | 0.696 | 0.800 |
| 17 | Skill, Strength, Speed and Working Conditions Disagreeable and Hazardous | | | | | | | | | | | | | | |
| 18 | Skill, Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 100 | 108 | 112 | 132 | 152 | 184 | 210 | 0.400 | 0.432 | 0.448 | 0.528 | 0.632 | 0.736 | 0.840 |
| | | 100 | 108 | 112 | 142 | 167 | 204 | 240 | 0.400 | 0.432 | 0.448 | 0.568 | 0.692 | 0.816 | 0.960 |

TABLE NO. II

Ratios of Occupational Rates to Minimum Rate

| | Factors To Be Considered When Classifying Occupations | Machine Charges Over $1.50 Per Hour — Skill Class | | | | | | | Machine Charges Over $2.50 Per Hour — Skill Class | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional |
| 1 | Speed | 104 | 104 | 104 | 108 | 110 | 112 | 114 | 106 | 106 | 106 | 108 | 110 | 112 | 114 |
| 2 | Strength | 104 | 108 | 110 | 112 | 116 | 120 | 124 | 106 | 110 | 112 | 114 | 118 | 122 | 126 |
| 3 | Men Hard to Get | 104 | 104 | 104 | 114 | 119 | 124 | 134 | 106 | 106 | 106 | 116 | 121 | 126 | 136 |
| 4 | Strength and Speed | 104 | 108 | 110 | 116 | 122 | 128 | 134 | 106 | 110 | 112 | 118 | 124 | 130 | 136 |
| 5 | Working Conditions Disagreeable and Hazardous | 104 | 104 | 104 | 114 | 124 | 134 | 144 | 106 | 106 | 106 | 116 | 126 | 136 | 146 |
| 6 | Skill | 104 | 108 | 110 | 114 | 124 | 134 | 144 | 106 | 110 | 112 | 116 | 126 | 136 | 146 |
| 7 | Speed and Working Conditions Disagreeable and Hazardous | 104 | 104 | 104 | 118 | 130 | 142 | 154 | 106 | 106 | 106 | 120 | 132 | 144 | 156 |
| 8 | Skill and Speed | 104 | 108 | 110 | 118 | 130 | 142 | 154 | 106 | 110 | 112 | 120 | 132 | 144 | 156 |
| 9 | Skill and Strength | 104 | 112 | 116 | 122 | 136 | 150 | 174 | 106 | 114 | 118 | 124 | 138 | 152 | 166 |
| 10 | Working Conditions Disagreeable and Hazardous and Men Hard to Get | 104 | 104 | 104 | 124 | 139 | 154 | 174 | 106 | 106 | 106 | 126 | 141 | 156 | 176 |
| 11 | Skill and Men Hard to Get | 104 | 108 | 110 | 124 | 139 | 154 | 174 | 106 | 110 | 112 | 126 | 141 | 156 | 176 |
| 12 | Strength, Speed and Working Conditions Disagreeable and Hazardous | 104 | 108 | 110 | 126 | 142 | 158 | 174 | 106 | 110 | 112 | 128 | 144 | 160 | 176 |
| 13 | Skill, Strength and Speed | 104 | 112 | 116 | 126 | 142 | 158 | 174 | 106 | 114 | 118 | 128 | 144 | 160 | 176 |
| 14 | Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 104 | 104 | 104 | 128 | 145 | 162 | 184 | 106 | 106 | 106 | 130 | 147 | 164 | 186 |
| 15 | Skill and Working Conditions Disagreeable and Hazardous | 104 | 108 | 110 | 124 | 144 | 164 | 184 | 106 | 110 | 112 | 126 | 146 | 166 | 186 |
| 16 | Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 104 | 108 | 110 | 136 | 157 | 178 | 204 | 106 | 110 | 112 | 138 | 159 | 180 | 206 |
| 17 | Skill, Strength, Speed and Working Conditions Disagreeable and Hazardous | 104 | 112 | 116 | 136 | 156 | 188 | 214 | 106 | 114 | 118 | 138 | 158 | 190 | 216 |
| 18 | Skill, Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 104 | 112 | 116 | 146 | 171 | 208 | 244 | 106 | 114 | 118 | 148 | 173 | 210 | 246 |

quality of paper. Years of training and experience have developed a very high, in most cases, exceptional skill. Speed and strength are requisites. Working conditions are disagreeable, due to the presence of continuous steam and moisture, and hazardous on account of revolving machinery. Men with sufficient experience are hard to get. In other words, he represents the highest type of requirements possible anywhere in the mill.

From Table I we find, under item 18, for exceptional skill, a ratio of 240; in Table II, for machine repair charges of over $1.50, a ratio of 244; for machine repair charges of over $2.50, a ratio of 246; in Table III, for machine repair charges of over $3.50, a ratio of 248, and for machine repair charges of over $5.00, a ratio of 254, establishing, on the basis of a minimum rate of 40c per hour, an hourly occupational rate, varying from 96c to 102c per hour for exceptionally skilled operators.

The various types of paper machines and different classes of paper do not require the same amount of skill, and in some cases average skill is sufficient. The ratio for average skill, (See Table I), being 112, we have a minimum hourly rate of 44.8c. This rate, for the purposes of the study, has been adjusted to 46c per hour. We have thus established a lower limit of 46c and an upper limit of 102c. This latter figure has been adjusted to 100c per hour to simplify tabulations.

The industry survey showed that 3,123 machine tenders for all types of paper machines are employed. A distribution of these employees by skill and hourly rate class, shown in Table IV, indicates that 1,480 employees fall within the rate class of 77c to 91c, and Table V shows that 2,831 employees or 90.66 per cent of the total are within the rate limits established above; 281 or 8.99 per cent above; and 11 or 0.35 per cent below the limits.

A similar analysis for beater engineers shows 1,012 employees or 98.92 per cent of the total of 1,023 people re-

TABLE NO. III

Ratios of Occupational Rates to Minimum Rate

| | Factors To Be Considered When Classifying Occupations | Machine Charges Over $3.50 Per Hour — Skill Class | | | | | | | Machine Charges Over $5.00 Per Hour — Skill Class | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional | Low | Ordinary | Avge. | Above Avge. | High | Very High | Exceptional |
| 1 | Speed | 108 | 108 | 108 | 112 | 114 | 116 | 118 | 114 | 114 | 114 | 118 | 120 | 122 | 124 |
| 2 | Strength | 108 | 112 | 114 | 116 | 120 | 124 | 128 | 114 | 118 | 120 | 122 | 126 | 130 | 134 |
| 3 | Men Hard to Get | 108 | 108 | 108 | 118 | 123 | 128 | 138 | 114 | 114 | 114 | 124 | 129 | 134 | 144 |
| 4 | Strength and Speed | 108 | 112 | 114 | 120 | 126 | 132 | 138 | 114 | 118 | 120 | 126 | 132 | 138 | 144 |
| 5 | Working Conditions Disagreeable and Hazardous | 108 | 108 | 108 | 118 | 128 | 138 | 148 | 114 | 114 | 114 | 124 | 134 | 144 | 154 |
| 6 | Skill | 108 | 112 | 114 | 118 | 128 | 138 | 148 | 114 | 118 | 120 | 124 | 134 | 144 | 154 |
| 7 | Speed and Working Conditions Disagreeable and Hazardous | 108 | 108 | 108 | 122 | 134 | 146 | 158 | 114 | 114 | 114 | 128 | 140 | 152 | 164 |
| 8 | Skill and Speed | 108 | 112 | 114 | 122 | 134 | 146 | 158 | 114 | 118 | 120 | 128 | 140 | 152 | 164 |
| 9 | Skill and Strength | 108 | 116 | 120 | 126 | 140 | 154 | 168 | 114 | 122 | 126 | 132 | 146 | 160 | 184 |
| 10 | Working Conditions Disagreeable and Hazardous and Men Hard to Get | 108 | 108 | 108 | 128 | 143 | 158 | 178 | 114 | 114 | 114 | 134 | 149 | 164 | 184 |
| 11 | Skill and Men Hard to Get | 108 | 112 | 114 | 128 | 143 | 158 | 178 | 114 | 118 | 120 | 134 | 149 | 164 | 184 |
| 12 | Strength, Speed and Working Conditions Disagreeable and Hazardous | 108 | 112 | 114 | 130 | 146 | 162 | 178 | 114 | 118 | 120 | 136 | 152 | 168 | 184 |
| 13 | Skill, Strength and Speed | 108 | 116 | 120 | 130 | 146 | 162 | 178 | 114 | 122 | 126 | 136 | 152 | 168 | 184 |
| 14 | Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 108 | 108 | 108 | 132 | 149 | 166 | 188 | 114 | 114 | 114 | 138 | 155 | 172 | 194 |
| 15 | Skill and Working Conditions Disagreeable and Hazardous | 108 | 112 | 114 | 128 | 148 | 168 | 188 | 114 | 118 | 120 | 134 | 154 | 174 | 194 |
| 16 | Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 108 | 112 | 114 | 140 | 161 | 182 | 208 | 114 | 118 | 120 | 146 | 157 | 188 | 214 |
| 17 | Skill, Strength, Speed and Working Conditions Disagreeable and Hazardous | 108 | 116 | 120 | 140 | 160 | 192 | 218 | 114 | 122 | 126 | 146 | 156 | 198 | 224 |
| 18 | Skill, Strength, Speed, Working Conditions Disagreeable and Hazardous and Men Hard to Get | 108 | 116 | 120 | 150 | 175 | 212 | 248 | 114 | 122 | 126 | 156 | 171 | 218 | 254 |

TABLE IV.
DISTRIBUTION OF EMPLOYEES FOR SELECTED OCCUPATIONS BY SKILL AND HOURLY RATE CLASS. (JUNE 19, 1935).

| OCCUPATION | Total Number of Employees in Group | Skill Class: Low | Ordinary | Average | Above Average | High | Very High | Exceptional | Not Rated |
|---|---|---|---|---|---|---|---|---|---|
| | | Hourly Rate Class: 40¢ and below | Over 40¢ to 46¢ | Over 46¢ to 53¢ | Over 53¢ to 65¢ | Over 65¢ to 77¢ | Over 77¢ to 91¢ | Over 91¢ to 100¢ | Over 100¢ |
| Machine Tenders | 3,123 | 2 | 9 | 98 | 287 | 777 | 1,480 | 189 | 281 |
| Beater Engineers | 1,023 | 0 | 17 | 63 | 307 | 350 | 243 | 32 | 11 |
| Head Pipe Fitters | 111 | - | - | 4 | 26 | 48 | 22 | 4 | 7 |
| Back Tenders | 3,008 | 138 | 161 | 518 | 1,365 | 520 | 155 | 80 | 71 |
| Millwrights | 3,284 | 195 | 358 | 563 | 1,273 | 754 | 118 | 23 | - |
| Pipe Fitters | 657 | 9 | 29 | 77 | 319 | 197 | 26 | - | - |
| Electricians (Shift) | 425 | 9 | 18 | 46 | 155 | 144 | 48 | 4 | 1 |
| Carpenters | 432 | 6 | 33 | 46 | 186 | 145 | 16 | - | - |
| Engine Oilers | 64 | 4 | 14 | 18 | 28 | - | - | - | - |
| Third Hands | 2,769 | 187 | 474 | 1,118 | 736 | 185 | 55 | 7 | 7 |
| Head Beater Men | 1,146 | 85 | 222 | 427 | 330 | 60 | 19 | 3 | - |
| Oilers | 935 | 104 | 251 | 315 | 217 | 39 | 7 | 2 | - |
| Chippermen | 358 | 64 | 88 | 140 | 66 | - | - | - | - |
| Pipe Fitter Helpers | 327 | 25 | 99 | 105 | 90 | 8 | - | - | - |
| Electrician Helpers | 99 | 5 | 6 | 57 | 25 | 4 | 2 | - | - |
| Beater Men | 3,376 | 509 | 1,741 | 906 | 220 | - | - | - | - |
| Broke Beater Men | 488 | 116 | 239 | 115 | 14 | 4 | - | - | - |
| Size Men | 231 | 33 | 77 | 75 | 43 | 3 | - | - | - |
| Yard Laborers | 2,375 | 827 | 1,304 | 208 | 35 | 1 | - | - | - |
| Wood Conveyor Men | 347 | 95 | 170 | 72 | 10 | - | - | - | - |
| Hatchet Men | 206 | 54 | 138 | 11 | 3 | - | - | - | - |
| Carpenter Helpers | 144 | 10 | 77 | 42 | 15 | - | - | - | - |
| Fourth Hands | 2,947 | 1,320 | 928 | 538 | 158 | 3 | - | - | - |
| Beater Men Helpers | 307 | 135 | 77 | 85 | 10 | - | - | - | - |
| Ash Handlers | 274 | 88 | 76 | 69 | 39 | 2 | - | - | - |

ported, are within the limits established by the ratios, and only 11 or 1.08 per cent above, with none below the limits. Other occupations common to all mills have been analyzed and the results compiled in Tables IV and V.

The ratios furnished in Tables I, II and III, inclusive, may not be absolutely correct. The illustrations of the applications in Tables IV and V indicate plainly, however, that intentionally or unintentionally the industry has applied a similar principle in their wage adjustments. Local problems or difference in type of communities, rural or otherwise, probably accounts for variations above or below the limits established by the ratios.

A careful study of the contents of Table V shows a reasonably close conformance to the limits found by the ratios for highly skilled and low skill occupations. Considerable variations from the limits set is very noticeable for intermediate occupations, with the greatest variations for occupations approaching the low skill classes. This tendency indicates the well-known fact that wages for highly skilled employees are usually carefully watched and controlled, while those for intermediate operations are more haphazardly set or adjusted.

Sufficient evidence for the reasonable accuracy of these ratios is shown in the outline above, to prove that their application can and will supply a valuable aid to all mills in the vital problem of wage rate adjustments on a comparable basis.

TABLE NO. V.—DISTRIBUTION OF EMPLOYEES WITHIN HOURLY WAGE RATE LIMITS ESTABLISHED ON BASIS OF OCCUPATIONAL REQUIREMENTS

| Occupation | Total Number of Employees | Hourly Rate Limits for Group | Number and Per cent of Employees Receiving Hourly Rate: Below Limits Set — Number Employees | Below Limits Set — Per cent of Total | Within Limits Set — Number Employees | Within Limits Set — Per cent of Total | Above Limits Set — Number Employees | Above Limits Set — Per cent of Total |
|---|---|---|---|---|---|---|---|---|
| Machine Tenders | 3,123 | Over 46c to 100c | 11 | 0.35 | 2,831 | 90.66 | 281 | 8.99 |
| Beater Engineers | 1,023 | Over 40c to 91c | 0 | 0.00 | 1,012 | 98.92 | 11 | 1.08 |
| Head Pipe Fitters | 111 | | 0 | 0.00 | 104 | 93.69 | 7 | 6.31 |
| Back Tenders | 3,008 | Over 40c to 77c | 138 | 4.59 | 2,564 | 85.23 | 306 | 10.18 |
| Millwrights | 3,284 | | 195 | 5.94 | 2,948 | 89.77 | 141 | 4.29 |
| Pipe Fitters | 657 | | 9 | 1.37 | 622 | 94.67 | 26 | 3.96 |
| Electricians (Shift) | 425 | | 9 | 2.12 | 363 | 85.41 | 53 | 12.47 |
| Carpenters | 432 | | 6 | 1.39 | 410 | 94.91 | 16 | 3.70 |
| Engine Oilers | 64 | | 4 | 6.25 | 60 | 93.75 | 0 | 0.00 |
| Third Hands | 2,769 | Over 40c to 65c | 187 | 6.75 | 2,328 | 84.06 | 254 | 9.19 |
| Head Beater Men | 1,146 | | 85 | 7.42 | 979 | 85.43 | 82 | 7.15 |
| Oilers | 935 | | 104 | 11.12 | 783 | 83.75 | 48 | 5.13 |
| Chippermen | 358 | | 64 | 17.88 | 294 | 82.12 | 0 | 0.00 |
| Pipe Fitter Helpers | 327 | | 25 | 7.65 | 294 | 89.90 | 8 | 2.45 |
| Electrician Helpers | 99 | | 5 | 5.05 | 88 | 92.93 | 6 | 2.02 |
| Beater Men | 3,376 | Over 40c to 53c | 509 | 15.07 | 2,647 | 78.41 | 220 | 6.52 |
| Broke Beater Men | 488 | | 116 | 23.77 | 354 | 72.54 | 18 | 3.69 |
| Size Men | 231 | | 33 | 14.29 | 152 | 65.80 | 46 | 19.91 |
| Yard Laborers | 2,375 | | 827 | 34.82 | 1,512 | 63.67 | 36 | 1.51 |
| Wood Conveyor Men | 347 | | 95 | 27.38 | 242 | 69.74 | 10 | 2.88 |
| Hatchet Men | 206 | | 54 | 26.21 | 149 | 72.33 | 3 | 1.46 |
| Carpenter Helpers | 144 | | 10 | 6.94 | 119 | 82.64 | 15 | 10.42 |
| Fourth Hands | 2,947 | 40c to 53c | 0 | 0.00 | 2,786 | 94.54 | 161 | 5.46 |
| Beater Men Helpers | 307 | | 0 | 0.00 | 297 | 96.74 | 10 | 3.26 |
| Ash Handlers | 274 | | 0 | 0.00 | 233 | 85.04 | 41 | 14.96 |

# Factors Affecting Retention*

By William R. Willets[1]

**Abstract**

*A laboratory investigation on the retention of fillers (and primarily on the retention of titanium dioxide) has shown that:*

*(1) Retention is increased by increasing the amount of alum up to 3 per cent (based on the weight of the fiber), after which the retention decreases slightly. The use of an excess of alum is less detrimental than the use of too small an amount. These statements hold true whether or not rosin size is used. While rosin, when used with alum, increases retention, the alum is probably the most important factor.*

*(2) The use of starch exerts a deleterious, rather than a beneficial, effect on retention. Starches vary in this respect, but none of those investigated were beneficial as far as retention was concerned.*

*(3) Hydration resulting from beating causes marked increases in retention.*

*(4) Retention increases with increasing basis weight. The effect of increasing the basis weight is most noticeable at the lower weights.*

*(5) An increase in temperature in the sheet machine causes marked increases in retention.*

*(6) Increased dilution in the sheet machine causes increases in retention.*

*(7) Retention is not primarily dependent on the characteristics of an insoluble filler. The role played by particle size, etc. is small compared to the effect of such factors as alum, temperature, dilution, hydration, basis weight, etc.*

*(8) The mechanism of retention is obscure. Retention is probably dependent on a combination of chemical, colloidal and mechanical factors, all of which play an important part, and all of which are closely correlated.*

*(9) It is obvious from the data of this report that in any investigation on retention, only one factor be varied at a time while maintaining the other factors as rigidly constant as possible.*

In an earlier paper *(23)* the writer attempted to review briefly some of the literature dealing with the retention of fillers. As was pointed out at that time, the literature regarding this subject, while not over-extensive, shows a wide discrepancy of opinion regarding some of the factors involved in the retention of fillers by the paper web.

The work reported herein was undertaken in an attempt to clear up certain of such factors which by their very nature permitted of laboratory investigation. Naturally many factors, such as machine speed, shake, suction, white water recovery and the like *(6)* *(11)* *(14)* *(15)* *(17)* *(18)* *(20)* do not permit of laboratory investigation. However, certain other factors—such as effect of chemicals, hydration, basis weight, temperature, dilution, etc.—may be studied in the laboratory with the end in view of obtaining data which may prove indicative of mill results.

## General Procedure

A good grade of domestic bleached sulphite pulp was used for all experiments. This was processed in a ¾ pound Noble and Wood beater, using 150 grams of pulp in 7.5 liters (2 per cent consistency). Before adding to the beater the pulp was thoroughly disintegrated by means of a high speed mixer. In general (except where studies were being made on the effect of hydration on retention) the stock was beaten for one hour.

After dumping, the stock was diluted to 15 liters, and an aliquot removed for freeness tests. For this purpose the aliquot was diluted to a consistency of 0.2 per cent at a temperature of 20 deg. C. The standard Schopper-Riegler apparatus was used for all measurements of beating degree. Although a definite attempt was made to maintain a standard beating degree, this was almost impossible because of the difficulties in setting so small a beater and in maintaining constant temperatures. However, wherever comparisons are made, the beating degrees were similar. In spite of the limitations of the small beater, it was considered as superior to the pebble mill, since the latter causes considerable ash from the pebbles and lining, and in no way approximates mill beating conditions.

The stock from the beater after dilution had a consistency of 1 per cent. Thirteen liters of this stock were diluted to 15 liters and 3 liter aliquots taken for stirring. Two percent rosin was added at the start, followed by alum 10 minutes later. Stirring was then continued for 5 additional minutes. Dry rosin size and iron free alum were used throughout the tests.

After completion of stirring, the 3 liters of stock were diluted to 4.5 liters, and one liter aliquots used for making sheets, except where the effect of basis weight was being studied in which case the volume of the aliquots was varied. This aliquot contained about 5.75 grams of stock. The dilution in the sheet machine (in all cases excepting those where the effect of dilution on retention was being studied) was 6 liters, giving a stock concentration of approximately 0.0925 per cent.

The sheets were made on a standard Valley sheet mold, having a wire (100 mesh) 10.5 x 10.5 inches. The only suction used was that obtained from the water leg furnished with the machine. The distance from the bottom of the wire to the bottom of the water leg was about 3 feet.

The sheets were couched on dry blotters by means of a brass roll two inches in diameter and weighing 16 pounds. They were pressed between the couch blotters, and subsequently between changes of fresh blotters, until relatively dry. Although a detailed record has been made of the pressing, it will not be noted here since the method of pressing, while of the utmost importance in strength testing, plays little part in retention studies. However, pressing, blotter changes, etc. were maintained constant.

In all cases, "blank," i.e. unfilled sheets were made under exactly identical conditions to the filled sheets so as to allow the determination of the ash content of the paper not resulting from the filler itself. This "blank ash" subtracted from the ash of the filled samples gave the ash resulting from the filler. The loss on incineration of the filler was determined, and this permitted the calculation of the amount of filler in the sheet. The amount added to the pulp was also known, so the percentage in the sheet divided by the percentage added (based on the total furnish) gave the per cent retention. For example, in the case of a clay having a loss on incineration of 13.5 per cent:—

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5 per cent clay added based on the weight of the pulp, or $\frac{5}{100 + 5} = 4.76$ per cent on basis of total furnish

| | |
|---|---|
| Ash of filled sheet | 3.82 per cent |
| Ash of blank | 0.95 per cent |
| Ash due to clay | 2.87 per cent |
| Clay in sheet | 2.87/0.865 = 3.31 per cent |
| Retention | 3.31/4.76 or 69.5 per cent |

### Effect of Alum

The effect of alum on the retention of fillers has been more or less of a disputed point. Atsuki and Nakamura *(3)* reported that retention was better at lower hydrogen ion concentrations. De Cew *(8)* reported that if a filler, and especially a colloidal filler, was used in conjunction with the coagulants of the sizing process the retention was improved. Goy *(9)* reported higher retentions when size and alum were used. Khinckin *(10)* considered retention a colloidal phenomenon in which alum played an important role. Kress and McNaughton *(11)* obtained much higher retentions in sized sheets than in unsized sheets. In their experiments the ratio of alum to size was maintained constant both being increased proportionally. Roschier *(14)* reported that on adding increasing amounts of alum the retention was first lowered and then increased. He also reported that when the alum was maintained constant, and the pH regulated by the addition of caustic soda, the retention increased with increasing pH. His experiments using a constant pH and varying amounts of alum indicated a slight initial decrease in retention followed by an increase, reaching a maximum at 6 to 8 per cent addition, followed by a slight decrease. Rather similar results were obtained by Stschegloff *(19)*. Rue and Ford *(15)* found much higher retentions in sheets sized with rosin and alum than in unsized sheets. Rue and Hallahan *(16)* reported that the addition of alum alone (without size) had little effect on the retention of clay, and that while 1 per cent alum did increase the retention of talc, larger amounts had little effect. In subsequent tests, in which 20 per cent (rather than 10 per cent) clay was used, it was found that the use of 3 per cent alum alone, and also in conjunction with 2.5 per cent rosin size, increased retention. The results were rather erratic.

The results of our tests are given in Table I-A and I-B and Fig. 1 It will be seen that alum increased the retention markedly, whether or not used in conjunction with rosin size. The retention reached a maximum at 3 per cent alum addition, after which there was a decrease. However, these data indicate that the effect of adding too much alum is far less detrimental than the effect of adding too little.

Apparently the use of rosin in conjunction with the alum gave slightly better retentions than the use of alum alone. However, there is a possibility that this difference was a result of the difference in beating degree rather than the use of size.

It is interesting to note that the ash of the unpigmented sheets increased with increasing amounts of alum regardless of whether or not rosin was used. However, where rosin was used the ash of the unfilled paper was higher than when alum alone was used.

Judging from the results, alum is the most important factor in securing good retention. Unless sufficient alum is used, retentions will be poor. It is interesting to note that this is quite in line with commercial practice.

TABLE I-A
EFFECT OF ROSIN AND ALUM ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| Rosin Added 2 Per cent Constant, Per cent Alum Added | A: pH at Sheet Machine | A: Per cent Ash of Blank | B: Per cent Ash of Pigmented Sheet | B: Per cent Titanium Dioxide | B: Per cent Retention | B: Basis Weight Lbs. 25x38—500 |
|---|---|---|---|---|---|---|
| 1 | 6.6 | 0.66 | 3.63 | 2.97 | 42.4 | 54.6 |
| 2 | 6.2 | 0.89 | 5.51 | 4.62 | 66.0 | 58.6 |
| 3 | 5.5 | 0.98 | 6.15 | 5.17 | 73.9 | 58.6 |
| 4 | 5.2 | 1.04 | 6.02 | 4.98 | 71.1 | 57.3 |
| 5 | 4.9 | 1.03 | 5.81 | 4.78 | 68.3 | 58.6 |

NOTES: 1. Stock beaten one hour in ¾ pound beater
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 22 deg. C. 22.5 deg. C.
Beating degree *A* 76.3 degrees Schopper-Riegler.
*B* 72.8 degrees Schopper-Riegler.
2. Temperature in sheet machine 70 deg. F.
3. 7.5 per cent Pigment added based on air dry fiber.

TABLE I-B
EFFECT OF ALUM ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| No Rosin Added, Per cent Alum Added | A: pH at Sheet Machine | A: Per cent Ash of Blank | B: Per cent Ash of Pigmented Sheet | B: Per cent Titanium Dioxide | B: Per cent Retention | B: Basis Weight Lbs. 25x38—500 |
|---|---|---|---|---|---|---|
| 0 | 7.0 | 0.42 | 1.64 | 1.22 | 17.9 | 55.0 |
| 1 | 6.5 | 0.53 | 2.63 | 2.10 | 30.0 | 56.1 |
| 2 | 6.0 | 0.78 | 5.07 | 4.29 | 61.3 | 57.6 |
| 3 | 5.4 | 0.86 | 5.62 | 4.76 | 68.0 | 58.2 |
| 4 | 5.0 | 0.92 | 5.50 | 4.58 | 65.4 | 56.7 |

NOTES: 1. Stock beaten one hour in ¾ pound beater.
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 22 deg. C. 22 deg. C.
Beating degree *A* 69.4 degrees Schopper-Riegler.
*B* 69.5 degrees Schopper-Riegler.
2. Temperature in sheet machine 70 deg. F.
3. 7.5 per cent Pigment added based on air dry fiber.

### Effect of Various Starches

There is a wide discrepancy of opinion on the effect of starches on the retention of fillers. Some investigators *(3)* *(4)* *(5)* feel that the use of beater starch improves retention, others *(1)* *(14)* have not found starch beneficial in this respect.

The results obtained in our tests (Table II) agree with the latter opinion. In fact, they showed that the use of starch actually caused a decrease in retention. Also it was

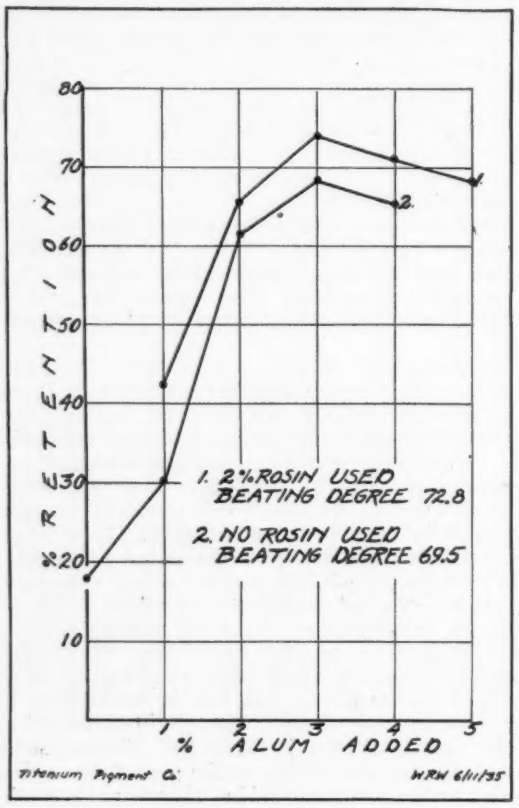


FIG. 1.
Effect of alum on retention.

found that certain starches have a more detrimental effect than others.

Just why this should be is a difficult question to answer. There is a possibility that the starch acts as a protective colloid and maintains the filler in such a well-dispersed state that it cannot be coagulated and fixed on the fiber, but passes through the filter mat of pulp initially formed on the wire.

TABLE II
EFFECT OF VARIOUS STARCHES ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| | A | B | | | |
|---|---|---|---|---|---|
| Starch | Per cent Ash of Blank | Per cent Ash of Pigmented Sheet | Per cent Titanium Dioxide | Per cent Retention | Basis Weight Lbs. 25x38—500 |
| None | 0.93 | 6.20 | 5.27 | 75.3 | 57.3 |
| Starch 1 | 0.92 | 5.77 | 4.85 | 69.4 | 56.8 |
| Starch 2 | 0.92 | 5.85 | 4.93 | 70.4 | 57.3 |
| Starch 3 | 0.95 | 5.67 | 4.72 | 67.4 | 58.6 |
| Starch 4 | 0.94 | 5.18 | 4.24 | 60.6 | 57.8 |

NOTES: 1. Sized with 2 per cent dry rosin size and 3 per cent alum.
2. Stock beaten one hour in ¾ pound beater.
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 22 deg. C. 22 deg. C.
Beating degree *A* 74.8 degrees Schopper-Riegler.
*B* 73.8 degrees Schopper-Riegler.
3. pH in sheet machine 5.5.
Temperature in sheet machine 70 deg. F.
4. 7.5 per cent pigment added based on air dry fiber.
5. Starches 1, 2 and 4—Modified cornstarch dissolved in hot water before adding.
Starch 3—"Cold Water" starch, added dry.

### Effect of Hydration

It is the general consensus of opinion that the hydration resulting from beating gives increased retention of fillers (*3*) (*6*) (*7*) (*9*) (*11*) (*13*) (*14*) (*20*). Cyster (*7*) reported that in an antique sheet made from free stock, 6.41 per cent of the fiber and 42.45 per cent of the filler passed through the machine wire, while for a well beaten litho sheet the amounts were 3.5 per cent and 11.4 per cent respectively. He concluded that beating had far more to do with retention than the type of clay used. With increasing hydration, Kress and McNaughton (*11*) noted an increase in retention from 83.6 to 91.9 per cent in a sheet sized with 2.5 per cent rosin and 5 per cent alum, and from 70.7 to 91.1 in a sheet sized with 2.5 per cent rosin and 3.5 per cent alum. (It should be pointed out, however, that the method for calculating retention in these cases gave misleading, high results). Roschier (*14*) obtained a retention of 44 per cent with unbeaten stock having a beating degree of 12 Schopper-Riegler, the retention increased on treatment of the pulp in a Lampen mill until it reached 74 per cent at 71 degrees Schopper-Riegler.

Similar results were obtained in our investigations. The data are given in Table III and Fig. 2. In these tests, handsheets were made from unfilled stock, and from stock containing 2.5, 5, 7.5 and 10 per cent of titanium dioxide, based on the air dry weight of fiber. It will be noted that in general the retention of the filler was approximately the same regardless of the amount used, although in one or two cases the data were a trifle erratic.

No doubt the increase in retention on beating is the result of increased fibrillation and reduction in the pore size of the initial "filter mat" of fiber laid down. It is a well known fact that beating results in a less porous and denser sheet, consequently there is less chance for a filler to pass through and be lost.

### Effect of Basis Weight

The literature is well agreed that retention increases with increasing basis weight (*6*) (*11*) (*13*) (*14*) (*15*) (*20*), and our results concur with this (Table IV, Fig. 3).

In these tests the only variation was the amount of stock added to the sheet machine, which would naturally result in variations in stock concentration and pH. The beating was identical for all the filled sheets; the amounts of size, alum, etc., and the temperature were maintained constant.

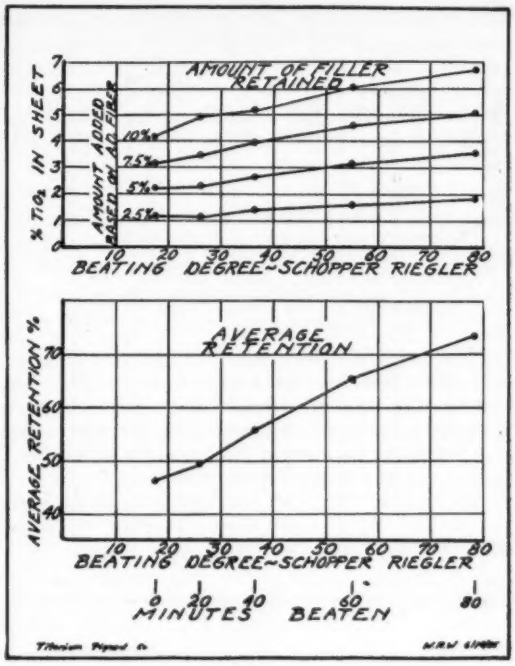


FIG. 2.
Effect of hydration on retention.

As will be noted, the greatest increase in retention with increasing basis weights was at the lower basis weights. In general, the same results were reported by Kress and McNaughton (*11*).

The explanation for this is rather simple. It has been reported (*2*) that in a 92 grams per square meter sheet,

TABLE III
EFFECT OF HYDRATION ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| Beater Time and Degree | Per cent Titanium Dioxide Added | Per cent Ash | Per cent Titanium Dioxide | Per cent Retention | Basis Weight Lbs. 25x38—500 |
|---|---|---|---|---|---|
| Unbeaten | 0 | 0.70 | ... | ... | 55.8 |
| 17.3 deg. S.R. | 2.5 | 1.83 | 1.13 | 46.3 | 55.6 |
| | 5.0 | 2.93 | 2.23 | 46.8 | 56.7 |
| | 7.5 | 3.87 | 3.17 | 45.5 | 56.3 |
| | 10.0 | 4.88 | 4.18 | 46.2 | 56.0 |
| | | | | Average 46.2 | |
| 20 Mins. | 0 | 0.85 | ... | ... | 55.6 |
| 26 deg. S.R. | 2.5 | 1.95 | 1.10 | 45.3 | 55.6 |
| | 5.0 | 3.12 | 2.27 | 47.7 | 55.6 |
| | 7.5 | 4.31 | 3.46 | 49.4 | 56.5 |
| | 10.0 | 5.71 | 4.86 | 53.5 | 56.0 |
| | | | | Average 49.0 | |
| 40 Mins. | 0 | 0.78 | ... | ... | 55.3 |
| 36.4 deg. S.R. | 2.5 | 2.12 | 1.34 | 54.9 | 56.7 |
| | 5.0 | 3.42 | 2.64 | 55.4 | 57.9 |
| | 7.5 | 4.69 | 3.91 | 55.8 | 58.2 |
| | 10.0 | 5.96 | 5.18 | 57.1 | 59.0 |
| | | | | Average 55.8 | |
| 60 Mins. | 0 | 0.86 | ... | ... | 55.0 |
| 55 deg. S.R. | 2.5 | 2.44 | 1.58 | 64.8 | 54.5 |
| | 5.0 | 3.94 | 3.08 | 64.8 | 57.2 |
| | 7.5 | 5.38 | 4.52 | 64.7 | 57.8 |
| | 10.0 | 6.87 | 6.01 | 66.3 | 58.2 |
| | | | | Average 65.2 | |
| 80 Mins. | 0 | 0.88 | ... | ... | 54.7 |
| 78.5 deg. S.R. | 2.5 | 2.66 | 1.78 | 73.0 | 57.2 |
| | 5.0 | 4.40 | 3.52 | 74.0 | 57.8 |
| | 7.5 | 5.95 | 5.07 | 72.8 | 59.4 |
| | 10.0 | 7.58 | 6.70 | 73.8 | 59.5 |
| | | | | Average 73.4 | |

NOTES: 1. Sized with 2 per cent dry rosin size and 3 per cent alum.
2. Stock beaten in ¾ pound beater.

| Beating temperatures— | At start deg. C. | At end deg. C. |
|---|---|---|
| Unbeaten | 20 | 20 |
| 20 mins. | 20 | 23.5 |
| 40 mins. | 20 | 23 |
| 60 mins. | 20 | 23 |
| 80 mins. | 20 | 27 |

3. Temperature in sheet machine 70 deg. F., pH 5.5-5.6.
Per cent titanium dioxide added based on air dry fiber.

TABLE IV
EFFECT OF BASIS WEIGHT ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| | | | A | B | | |
|---|---|---|---|---|---|---|
| Basis Weight Lbs. 25x38—500 | Volume Stock Used per Sheet cc. | pH in Sheet Machine | Per cent Ash of Blank | Per cent Ash of Pigmented Sheet | Per cent Titanium Dioxide | Per cent Retention |
| 29.4 | 500 | 6.4 | 0.89 | 5.51 | 4.62 | 66.0 |
| 44.4 | 750 | 6.0 | 0.96 | 6.20 | 5.24 | 74.9 |
| 59.5 | 1000 | 5.6 | 0.97 | 6.46 | 5.49 | 78.4 |
| 73.3 | 1250 | 5.4 | 0.96 | 6.67 | 5.71 | 81.6 |
| 89.0 | 1500 | 5.2 | 0.93 | 6.73 | 5.80 | 82.9 |

NOTES: 1. Sized with 2 per cent dry rosin and 3 per cent alum.
2. Stock beaten one hour in ¾ pound beater.
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 22 deg. C. 21.5 deg. C.
Beating degree *A* 72.5 degrees Schopper-Riegler.
*B* 76.5 degrees Schopper-Riegler.
3. Temperature in sheet machine 70 deg. F.
4. 7.5 per cent pigment added based on air dry fiber.

having an average ash content of 28.8 per cent, the top side of the sheet had an ash content of 29.6 per cent and the under side of only 25 per cent. Owing to the withdrawal of water the sheet first became compacted next to the wire, forming a filter mat in which the filling material from the upper layers was caught. It is logical to assume that as this filter mat increases in thickness and weight, it will retain more filler; in other words, as the basis weight increases, the retention increases.

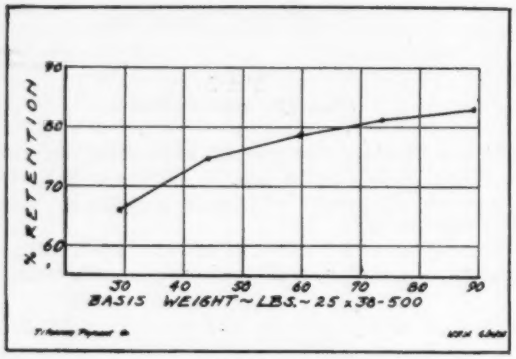


FIG. 3.
Effect of basis weight on retention.

### Effect of Temperature

As far as could be ascertained, the literature contains no references on the effect of temperature on the retention of fillers. However, since it is generally conceded that retention depends to a considerable extent on colloidal phenomena (in which temperature plays an important role) this factor was thought worthy of investigation.

The results are given in Table V and Fig. 4. It will be noted that with an increase in temperature in the sheet machine the ash content of the unfilled sheets increased very slightly, but steadily, which would seem to indicate that one of two things occurred, a greater precipitation

TABLE V
EFFECT OF TEMPERATURE ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| | A | B | | | |
|---|---|---|---|---|---|
| Temperature in Sheet Machine deg. F. | Per cent Ash of Blank | Per cent Ash of Pigmented Sheet | Per cent Titanium Dioxide | Per cent Retention | Basis Weight Lbs. 25x38—500 |
| 43 | 0.87 | 5.40 | 4.53 | 64.7 | 57.3 |
| 60 | 0.90 | 6.00 | 5.10 | 72.9 | 57.8 |
| 70 | 0.91 | 6.41 | 5.50 | 78.6 | 58.2 |
| 85 | 0.94 | 6.72 | 5.78 | 82.6 | 58.6 |
| 100 | 0.95 | 7.02 | 6.07 | 86.7 | 59.0 |

NOTES: 1. Sized with 2 per cent dry rosin size and 3 per cent alum.
2. Stock beaten one hour in ¾ pound beater.
Beating temperature at start *A* 21 deg. C. *B* 20 deg. C.
at end 24 deg. C. 24 deg. C.
Beating degree *A* 74.2 degrees Schopper-Riegler.
B 73.5 degrees Schopper-Riegler.
3. pH in sheet machine 5.5.
4. 7.5 per cent pigment added based on air dry fiber.

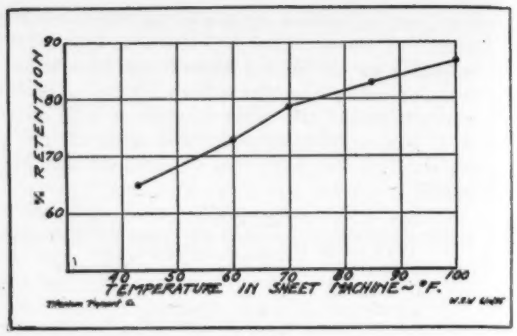


FIG. 4.
Effect of temperature on retention.

of size and alumina, or a greater fixation of the "natural ash" of the fiber.

The retention of the pigment (titanium dioxide) was increased very considerably with an increase in temperature. This increase in retention with increasing temperatures in the sheet machine is exceedingly difficult to explain, and any attempted explanations must of necessity be only the roughest kind of hypotheses. There is a possibility that the increased temperatures increased the colloidal affinities between filler and fiber, and also between the size and fiber, which latter phenomenon might result in a greater "cementing" action of the filler on the fiber.

It is difficult to judge whether or not these experimental results would prove practical in mill operation, since there seems to be a good deal of feeling that sizing at higher temperatures is not satisfactory. Also there would be the necessity of heating up the stock and maintaining constant temperatures. No claims are made for the possibility of reducing these purely laboratory results to commercial practice but they may furnish food for thought. At least they emphasize that it is highly essential to maintain a given temperature in all experimental work dealing with retention.

### Effect of Dilution

It has been generally held that the retention of fillers decreased with increasing dilution of the stock on the machine wire (*14*) (*16*) (*20*). Unfortunately the literature contains comparatively little experimental evidence to bear out this belief, although Roschier (*14*) states that in very small scale experiments, in which 15 per cent of clay was added to 2.5 grams of pulp followed by 2 per cent alum, the retention was 48 per cent at a 1:200 dilution, 43 per cent at a 1:400 dilution and 40 per cent at 1:600 dilution (with sheets weighing 80 to 90 grams per square meter). Lorenz and Stopp (*13*) also considered that increased pulp concentrations tended to give increased retention, but their data appeared rather erratic.

The tests reported herein (Table VI, Fig. 5) were undertaken with the object in mind of maintaining all other factors rigidly constant and varying only the dilution in the sheet machine. Naturally, this variation in dilution did affect the pH in the sheet machine, but the amount of filler, size, and alum used, as well as the basis weights, were not varied.

There was a definite increase in the ash content of the unfilled sheets with decreasing concentration of the stock. There was likewise an increase in retention of pigment in the filled sheets. The retention increased considerably when the concentration was lowered from 1.927 to 1.156 grams per liter, but remained virtually constant as the concentration decreased from that point.

These results are difficult to explain. Possibly some

TABLE VI
EFFECT OF DILUTION ON THE RETENTION OF TITANIUM DIOXIDE (TITANOX-A)

| Dilution in Sheet Machine, Liters | Approx. Conc. of Stock in Sheet Machine, Grams/Liter | pH in Sheet Machine | A: Per cent Ash of Blank | B: Per cent Ash of Pigmented Sheet | B: Per cent Titanium Dioxide | B: Per cent Retention | Basis Weight Lbs. 25x38—500 |
|---|---|---|---|---|---|---|---|
| 3 | 1.927 | 4.8 | 0.79 | 5.66 | 4.87 | 69.6 | 52.8 |
| 5 | 1.156 | 5.3 | 0.88 | 6.17 | 5.29 | 75.6 | 52.8 |
| 7 | 0.826 | 5.6 | 0.94 | 6.27 | 5.33 | 76.1 | 52.8 |
| 9 | 0.642 | 5.9 | 1.03 | 6.33 | 5.30 | 75.7 | 54.1 |
| 11 | 0.525 | 6.2 | 1.07 | 6.45 | 5.38 | 76.9 | 54.1 |

NOTES: 1. Sized with 2 per cent dry rosin size and 3 per cent alum.
2. Stock beaten one hour in ¼ pound beater.
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 23.5 deg. C. 25 deg. C.
Beating degree *A* 67.0 degrees Schopper-Riegler.
*B* 72.5 degrees Schopper-Riegler.
3. Temperature in sheet machine 70 deg. F.
4. 7.5 per cent pigment added based on air dry fiber.

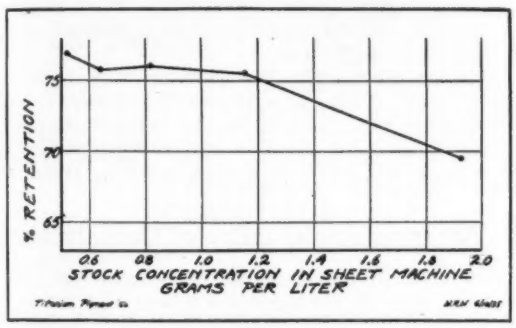


FIG. 5.
Effect of dilution on retention.

colloidal phenomena entered into the picture in which at the more dilute concentrations, the affinity of the filler and fiber were increased, or at which there was a greater precipitation of size and alumina. At any rate, the results obtained by the writer are rather at variance with those published in the literature; in other words, if all other factors—basis weight, temperature, hydration, size and alum—were maintained constant, the retention tended to increase with decreased concentrations of stock on the machine wire. Just how far these results would be applicable to mill practice is decidedly uncertain, but they do emphasize the necessity of controlling the dilution of the stock on the machine wire if comparable results are to be obtained in any study of retention.

TABLE VII
RETENTION OF VARIOUS FILLERS

| Filler | Per cent Ash of Filled Sheet: Addition 5% A | Addition 10% B | Per cent Filler: Addition 5% A | Addition 10% B | Per cent Retention: Addition 5% A | Addition 10% B | Average | Basis Weight, Lbs. 25x38—500: Addition 5% A | Addition 10% B |
|---|---|---|---|---|---|---|---|---|---|
| Titanox-A | 4.44 | 7.75 | 3.50 | 6.82 | 73.5 | 75.1 | 74.8 | 59.3 | 61.7 |
| Titanox-B | 4.24 | 7.29 | 3.30 | 6.36 | 69.3 | 70.1 | 69.7 | 58.8 | 61.7 |
| Clay | 3.82 | 6.79 | 3.31 | 6.72 | 69.5 | 73.7 | 71.6 | 59.6 | 60.8 |
| Talc | 4.44 | 8.08 | 3.59 | 7.31 | 75.5 | 80.1 | 77.8 | 58.8 | 59.8 |
| Bentonite | 3.72 | 6.45 | 3.15 | 6.26 | 66.2 | 68.8 | 67.5 | 58.0 | 57.5 |

NOTES: 1. Sized with 2 per cent dry rosin size and 3 per cent alum.
2. Stock beaten one hour in ¼ pound beater.
Beating temperature at start *A* 20 deg. C. *B* 20 deg. C.
at end 26 deg. C. 27 deg. C.
Beating degree *A* 77.1 degrees Schopper-Riegler.
*B* 79.0 degrees Schopper-Riegler.
3. pH in sheet machine 5.5, temperature 70 deg. F.
4. Loss on incineration: Titanox-A and B 0.25 per cent.
Clay 13.5 per cent.
Talc 2.8 per cent.
Bentonite 12.0 per cent.
5. Ash of "blank" unfilled sheet 0.95 per cent.
6. Per cent filler added based on air dry fiber.

### Retention of Various Fillers

The retention of various fillers has been reported by a great many investigators (*4*) (*6*) (*9*) (*12*) (*15*) (*16*) (*18*) (*20*) (*21*) (*22*). It is virtually a universal opinion that soluble fillers, such as the various forms of calcium sulphate, will be poorly retained because of their solubility (*6*) (*18*) (*20*). This fact was so obvious that soluble fillers were not included in our investigations.

The fact that clays may differ somewhat in their retention has been pointed out in several cases (*15*) (*16*) (*21*). However, another investigator determined the retention of two clays having widely different degrees of plasticity and "fatness," and found their retentions were virtually the same (*4*). Likewise, tests run at the U. S. Bureau of Standards indicated that various types of clays had similar retention properties (*18*). Others have undertaken experiments on different elutriation fractions of the same clay, but concluded that an elutriation analysis would only indicate to a very limited extent the retention properties of a clay (*15*) (*16*). Special colloidal clays, such as bentonite and wilkinite have been reported to be better retained than ordinary clays (*22*).

The results of most investigators indicate that talc is better retained than clay (*12*) (*18*); however, in one case it was reported that this was the case (*15*) but later work apparently refuted these earlier data (*16*).

It is generally held that the retention of fillers having a high specific gravity is less than that of those having lower specific gravity (*6*) (*15*) (*20*). This explanation is generally given for the poor retention of the barium sulphate fillers.

The foregoing brief and incomplete literature review will indicate somewhat the general indefiniteness regarding the relative retention properties of various paper fillers. In our investigations, we studied only five different materials, two opaque pigments, a typical clay (supposedly having good retention properties), bentonite (a highly colloidal clay) and talc. The results are given in Table VII.

It will be noted that the results check those investigators who claim good retention for talc. This material had the highest retention of those investigated. However, it should be pointed out that these results may hold true only for the particular talc studied, and very possibly might not apply to talcs as a class. In spite of the fact that its specific gravity (3.9) is much higher than that of clay (2.6), titanium dioxide was better retained than clay. Titanox-B (75 per cent blanc fixe and 25 per cent titanium dioxide) was retained practically as well as the clay, though its specific gravity is still higher (4.3). Bentonite had the lowest retention of all the fillers investigated.

Evidently specific gravity has less to do with retention than many other factors, and the same may be said for particle size, since the five fillers studied varied considerably in this property as well.

### The Mechanism of Retention

In discussing the theories which enter into the phenomena connected with the loading of paper it must be clearly borne in mind that it is easier to find out "what happens" than it is to explain "why it happens." No doubt this accounts for the widely divergent theories found in the literature.

Atsuki and Nakamura (*3*), Roschier (*14*) and others apparently believe that the retention of fillers is a mechanical and not a colloidal process. On the other hand, de Cew (*8*), Khinckin (*10*) and Stschegloff (*19*) consider that retention is largely a colloidal process. Probably the truth lies in the statement that retention is the result of a

combination of chemical, colloidal and mechanical processes.

A great deal of work has been done on the effect of particle size on retention, and it has generally been held that larger particles are better retained than small ones. However, in our own investigations it has been strongly indicated that particle size plays little part in retention since very finely divided titanium dioxide was retained better than coarser particled clay. After all, it makes comparatively little difference what the initial particle size may be if those particles are to be subsequently acted upon by dispersing media such as size, and still later by an agglomerating material such as alum.

For example, if a suspension of titanium dioxide is thrown on a filter paper especially designed to retain very fine particles, most of the pigment will pass through into the filtrate. If a little alum (or some other agglomerating material such as ammonium chloride) is added, the pigment is retained on the filter and the filtrate becomes clear. If a suspension of pigment is made in certain starch solutions, it is virtually impossible to agglomerate the pigment sufficiently to prevent its passing through the filter. (This probably explains the detrimental effect of starch on retention.)

In the formation of a web of filled paper, a dilute suspension of stock is thrown on the machine wire. Almost immediately a thin web of fibers is formed on the wire, and this acts as a filter mat to catch the fibers and filler still in suspension from which the water is being drawn off. If the filler is still in a very fine state, in other words, if it has not been agglomerated by the action of alum, it will pass through this thin fllter mat. Naturally if the pores of the mat are small, as in the case of well beaten stock, less material will be drawn through than if the pores are large, as in the case of free stock. Also, if the filler is maintained in its very fine state by the use of some material which possibly acts as a protective colloid and dispersing agent, such as starch, more filler will also pass through. As the thickness of the mat increases (i.e., as the basis weight increases) more material will be caught and held by it.

The exact role of alum is uncertain. It is evident that it increases retention, but whether this is entirely due to its agglomerating action, or whether alum possibly tends to mordant the extremely fine filler on the fiber, are moot points. Without a doubt, colloidal charges and affinities also play important parts, at least up to the point where these affinities are satisfied, after which the process probably becomes one of mechanical filtration.

It is also difficult to explain why an increase in temperature causes an increase in retention. Possibly here again the increases in retention result from obscure changes in the colloidal nature of the materials involved, caused by the increased temperatures.

At any rate, the phenomena of retention offer a very interesting field in which far more work could, and should be done. The writer appreciates the fact that he has merely grazed the surface.

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## Papermaking Quality of Cornstalks

Paper from cornstalks would cost more than papers made from wood according to the results of recent studies made at the National Bureau of Standards. An investigation of the papermaking quality of cornstalks was made by bureau scientists to find just what the possibilities are for converting a part of this annual farm waste into paper. They succeeded in making clean, white writing paper despite serious difficulties presented by the structural characteristics of the plant, and by the excessive amounts of dirt always clinging to field gathered stalks. However, from a consideration of the costs, it does not appear that cornstalks can compete successfully with wood as a raw material for paper under present conditions.

Special mechanical preparation of the stalks was found essential to successful pulping with chemicals, due to structural peculiarities of the type of plant stem. The hard outside part of the stem contains the bulk of the fibers of suitable length for paper, and most satisfactory results in pulping were obtained by using only this outside shell or cortex. The cortex was separated from the pith, and shredded by special mechanical processes.

The cornstalk fibers were found to be too brittle for use in ordinary brown wrapping papers where strength is the prime requisite, and although satisfactory writing papers were made, the yields were very low. The results indicated that less than half as much paper can be made from a ton of stalks as from the equivalent weight of wood. Also, cornstalks are so light and bulky that much more pulping equipment and chemicals are required than for wood. From a consideration of all of the costs involved in making paper from cornstalks as compared to wood, it is estimated that the stalks could not compete successfully with wood, even if wood were to double in price, unless profitable uses are developed for by-products or parts of the stalk not used in paper.

This work is reported in the Bureau Miscellaneous Publication 147 by C. G. Weber, M. B. Shaw, and M. J. O'Leary.

# The Formation and Structure of Cellulose Membranes*

By Wanda K. Farr[1]

During the past century the combined research of both botanists and chemists in the field of cellulose analysis has contributed but little of fundamental importance to our knowledge of cellulose. In a recent publication Khouvine (*1*) has called attention to the fact that an attempt to define the word cellulose merely serves to remind us that it is a substance which we are not able to crystallize, which has no fusion point, which will not dissolve in ordinary chemical solvents, whose structural formula has been somewhat evasive, and whose molecular weight is definitely uncertain.

From the botanical viewpoint, however, there are certain general properties of cellulose which are worthy of special consideration. It is, in the first place, a product of living protoplasm and, once formed, is used most extensively in constructing a wall around the protoplast. In some instances it is then in such a remarkable state of purity that "cell-wall" and "cellulose" are used synonomously.

### Cellulose Bacteria

Through the courtesy of Harold Hibbert we have had the privilege of analyzing microscopically cellulose membranes of bacterial origin from his cultures of *Acetobacter xylinus*. It has been well established by Doctor Hibbert and his coworkers *(2)* that these membranes respond to all of the tests for real cellulose. Their optical and chemical properties as well as the manner in which they diffract X-rays are identical with those of the cellulose from many other sources in the plant kingdom. Microscopic analysis has shown *(3)* the double refraction of polarized light by the bacterial "membrane," by a single chain of the bacteria, and even by one bacterium itself. The single bacterium shows parallel extinction and is in the position of greatest brightness when its long axis is at an angle of 45 degrees with the direction of the beam (Fig. 1, a). Treatment with iodine and sulphuric acid produced the swelling and the blue color characteristic of cellulose. As a result of such observations it becomes evident that the cellulose is a part of the bacterial organism itself and that it is not being synthesized from the culture medium by enzymes of bacterial origin. There is, moreover, a coating of non-cellulose material upon each bacterium which serves as its contact surface with the nutrient solution. The bacterial cellulose is therefore the product of the living protoplasm of the bacterium and the method of its formation from the available food materials is still linked inextricably with the life processes of the organism.

It is obvious from these results that certain types of microscopic technique may be used profitably in conjunc-

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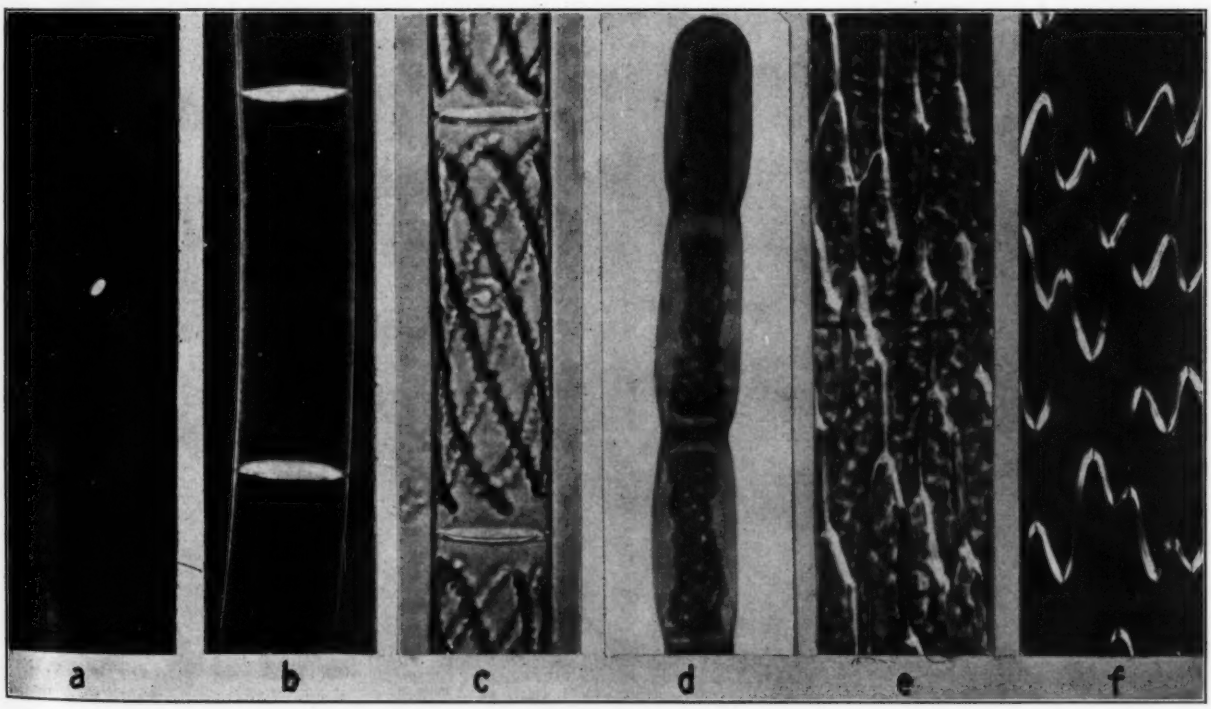


FIG. 1

a, Cellulose bacterium in polarized light, × 1440; b, c, cells of Spirogyra in polarized light, × 630; d, reaction to iodine and sulphuric acid in Spirogyra, × 350; e, f, cells of moss leaf in polarized light, × 550.

tion with the usual chemical and X-ray diffraction analyses. To the optical behavior in polarized light and the reaction in sulphuric acid and iodine, we may add measurements of the refractive indices both lengthwise and crosswise which, for cellulose, are 1.565 and 1.530 respectively. The presence of certain forms of non-cellulose material in the membrane may be detected by solubility tests and their location determined by staining with ruthenium red. These latter analyses have led to the opinion that the substance coating the surfaces of the bacterium is largely pectic (*3*).

### Cellulose Reactions In Various Cell Membranes

These forms of technique may be applied to many other types of plant cells having cellulose membranes with similar results. If the cylindrical cells of the filamentous alga *Spirogyra* are placed in the proper position with relation to the beam of polarized light they, too, are seen to have thin walls of cellulose (Fig. 1, b). With the selenite plate the longitudinal walls are blue when the cross-walls are yellow, indicating, through this color differentiation, that the cellulose units responsible for the double refraction are definitely oriented with respect to the surface of the protoplasm. With proper staining a non-cellulose layer may be found upon the outer surfaces of the cells and its presence may be detected between the cross-walls of two adjacent cells both by staining and by its non-double refraction (Fig. 1, c). When the filaments are treated with sulphuric acid and iodine the cellulose membrane swells and turns blue presenting the general appearance shown in Fig. 1, d. There is, therefore, no observed difference in the reactions of the cellulose in the cell of the single bacterium and that of the chain of cells in the alga.

The optical properties of the cellulose membranes of a multicellular tissue may be shown in a thin, untreated moss lead. Portions of the wall parallel to the beam are extinct and only those approaching the positions of greatest brightness are evident in polarized light with (Fig. 1, e) and without (Fig. 1, f) the selenite plate. These membranes react similarly to those previously described when treated with iodine and sulphuric acid. With these few simple forms of technique we may accomplish much in a detailed analysis of the more complex types of cellulose membranes found in higher plants.

### Cell Membrane Formation In the Cotton Fiber

In the cytoplasm of the young cotton fiber there are large numbers of ellipsoid particles, remarkably uniform in size and separate or in beadlike strands (*3*). In Fig. 2, a, many such particles are lying approximately parallel to the long axis of the young, living fiber. When this axis is at an angle of 45 degrees with the beam of polarized light, the particles are clearly doubly refractive; when the axis is parallel to the beam, they are extinct. Separate particles and short chains are found in the central regions of the cell. In the outer portions of the protoplast the chains are longer and, in some of them, the particles are so closely appressed end to end, that they have lost their

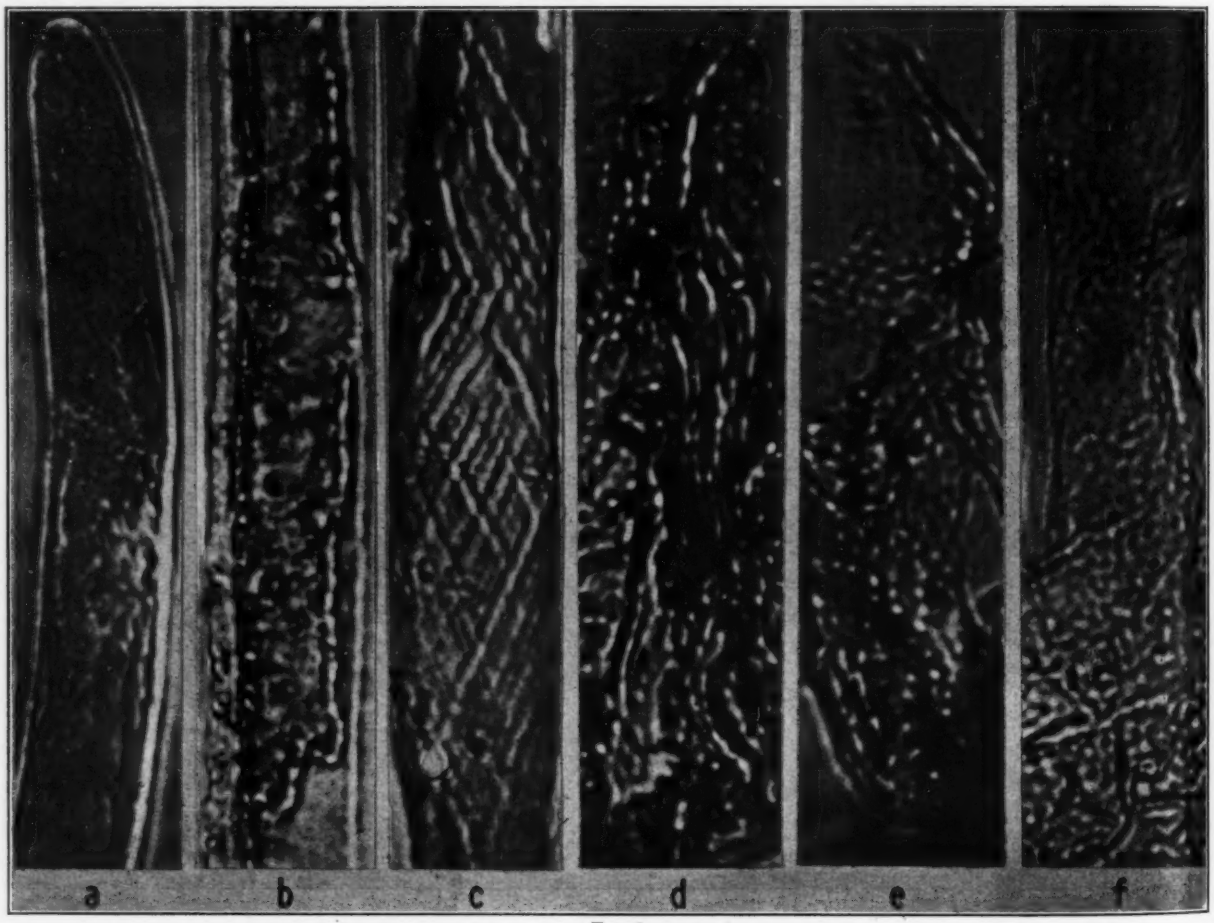


FIG. 2

**Cellulose particles and fibril formation in young cotton fibers. a × 1020 enlarged to 1400; b, f × 1500; c, crossed spiral fibrils in young cotton fiber, × 900 enlarged to 1500; d, e, mechanical disintegration of membranes of maturing cotton fibers, × 1500.**

separate identity. It is in this fashion that the cellulose fibril comes into existence. The next and final step in the process consists in the close appression of the fibril to the outer membrane. If the fibrils are the first to have been formed, they are attached to the outer non-cellulose covering of the protoplast. Later they are fastened to previously affixed layers of fibrils, the final thickness of the wall depending upon the extent to which the formation and deposition takes place. A portion of a young fiber slightly swollen in a weak alkaline solution (Fig. 2, b) and another which has been sectioned after imbedding in paraffin (Fig. 2, f) illustrate these same general points. In fibers taken from a boll on the fourteenth day from the date of flowering, the fibrils are shown in the typical crossed-spiral position (Fig. 2, c).

The membrane of a young fiber may be rupturel and some of the particles withdrawn for further examination. The lengths of the major and minor axes of the ellipsoids are approximately 1.5 /u and 1.1 /u respectively. The separate particles show a weak double refraction in polarized light and parallel extinction. Their brightness may be greatly increased, however, by treatment with dilute acids or alkalies, thus removing the outer layer of non-doubly refractive, non-cellulose material from their surfaces. Their refractive indices are 1.565 lengthwise and 1.530 crosswise. In iodine and sulphuric acid they swell and take on the blue coloration characteristic of cellulose. These observations, along with the previously described function of the particles in membrane formation, leave little doubt as to their cellulose nature.

The importance of the material which coats the surfaces of the particles and serves to bind them together in the process of membrane formation must not be overlooked. Its solubility in weak acids and alkalies, its non-double refraction and its staining with ruthenium red have led us to believe that it is composed largely of pectic substance. The intimate association of the particles with the living cytoplasm is sufficient basis, however, for the belief that traces of many other materials may also be represented. The amount by weight, of this material in the membrane is very small, probably not more than one or two per cent.

### Cell Membrane Degradation In the Cotton Fiber

If the process of cellulose membrane formation takes place as described, the mature membranes should break down into fibrils and the fibrils in turn into particles identical with those seen in the living cytoplasm. Many forms of treatment to bring about this wall degradation suggest themselves, but one of the most promising is that of a known solvent of pectic material. This has been accomplished effectively by means of hydrochloric acid (*4*). The various stages of membrane degradation are shown in *a*, *b*, and *c* of Figure 3. In *d* of the same figure, the reaction of the separated particles to treatment with sulphuric acid and iodine is shown. The swelling is seen to have been

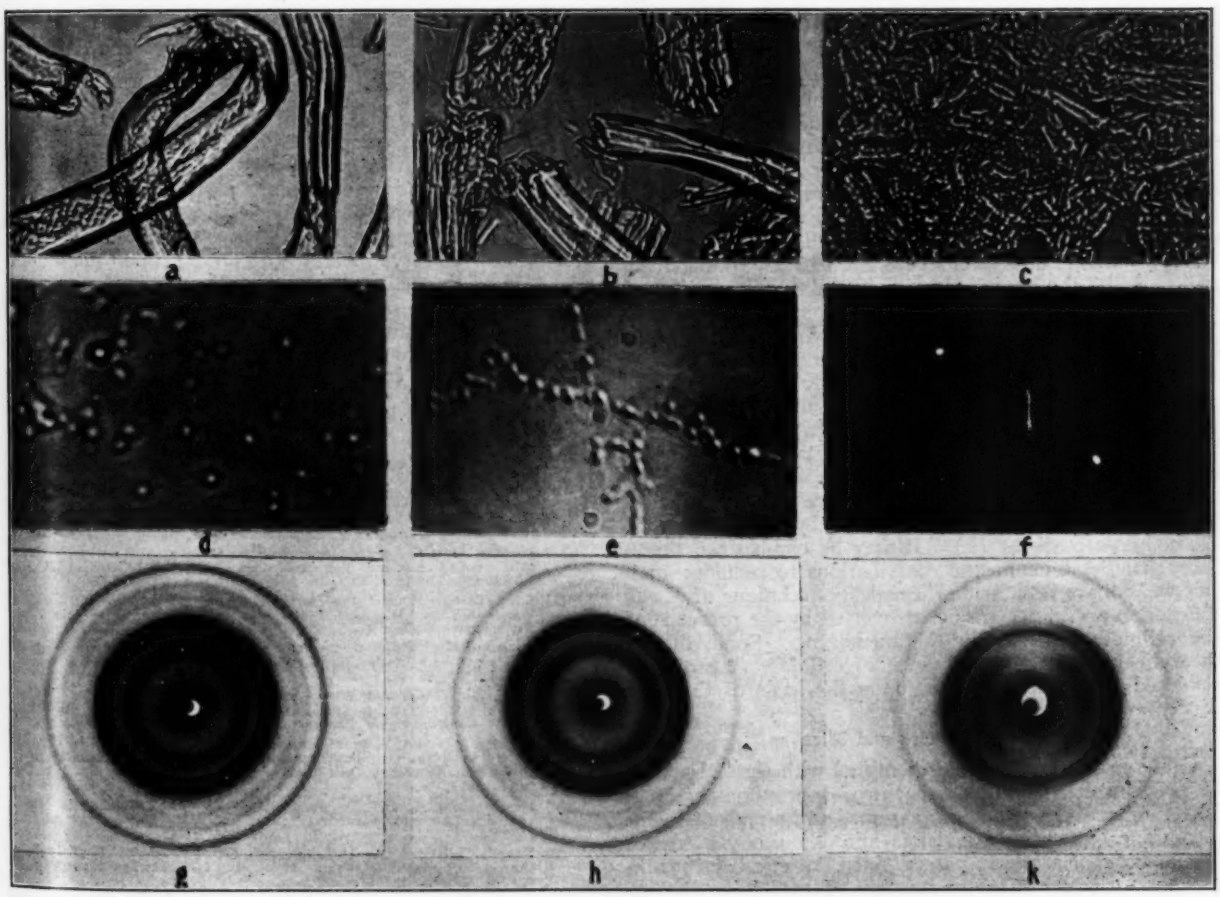


FIG. 3

a, b, c, Cotton fiber degradation by treatment with HCl, × 350; d, iodine-sulphuric acid reaction of separated cellulose particles, × 1380; e, separated particles, × 1630; f, two cellulose particles in polarized light, × 1380; g, h, i, X-ray diffraction patterns of separated cellulose particles, ground cotton fibers and paralleled cotton fibers.

greater in the direction of the short axis than in that of the long, thus producing a spherical instead of an ellipsoid shaped structure. More completely separated particles at higher magnifications are shown in Fig. 3, *e* and the double refraction in polarized light of two separated particles in Fig. 3, *f*.

X-ray diffraction patterns of masses of similar particles contribute additional evidence as to their cellulose nature (*5*). The diffraction pattern of the cellulose particles may be compared directly with patterns from ground cotton and paralleled cotton fibers shown in Fig. 3, *g*, *h*, and *k*, respectively.

### Material for Further Chemical Analysis

Macrochemical separations of the cementing material by means of a representative series of standard pectic solvents have been carried out more recently. The details of these results will appear soon in a forthcoming issue of the Contributions of the Boyce Thompson Institute. As a result of these separations considerable quantities of the two main membrane components, cellulose particles and cementing material, are now available for further chemical analysis.

Membranes of well-developed fibers, in which the process of dehydration has not begun, may be separated into their constituent microscopic structural units by mechanical means alone, without the use of the pectic solvents. The disintegration of such membranes into fibrils and particles is shown in Fig. 2, *d* and *e*. It is not possible to infer, in this instance, that the separations were "obtained by the action of oxidizing agents or of acids which tend to modify the cellulose" (*6, p. 291*).

### Cellulose Particles and Cellulose Unit Cells

The description of a unit structure such as the cellulose particle, whose chemical and optical properties so closely parrallel those already established for the entire membrane, arouses interest in its size relationships to other structural units of the membrane. From many X-ray diffraction analyses the cellulose unit cell is known to have the approximate dimensions of 8.3 x 10.3 x 7.9 Angstrom Units. With this same unit of measure the dimensions of the microscopically visible cellulose particle are then 10,000 x 15,000 Å. It is obvious, therefore, that the cellulose particles are not the regularly arranged structures of molecular dimensions which diffract X-rays. They are presumably aggregates of the cellulose unit-cells and play an important part in their gross orientation in the membrane. It has been pointed out that certain X-ray diffraction phenomena which heretofore have seemed to necessitate the assumption of the existence of hypothetical "miscellae" are explained equally well by the presence of the cellulose particles (*5*). It may be emphasized therefore, that the fundamental contributions to cellulose analysis which have been made through the technique of X-ray diffraction are in no sense controverted by the presence of the cellulose particles in the membrane. Some of the theoretical phases of this branch of cellulose research are rendered untenable, however, upon the basis of this new conception of membrane structure.

### Cellulose Particles and Micellae

Cellulose particles are not identified with the "Micellae" of previous investigators, structures approximately 50 x 500 Å in size (*7*) which are assumed to be present in the membrane but entirely invisible microscopically. Almost one hundred years have passed since the micellar hypothesis was originated for the purpose of explaining the appearance of starch and cellulose in polarized light as well as their behavior during swelling (*8, 9*). The material was considered to be crystalline because it was doubly refractive. Since the crystallites were not observed microscopically, their size was supposed to be below the limits of microscopic observation. After swelling with water the material apparently returned to its original state when dried. This indicated that the water had been held between the invisible crystalline micellae and had forced them apart without affecting them chemically. These well-known properties of the membranes are particularly interesting upon the basis of the conception of membrane structure now presented. There is crystalline material, but in the form of microscopic cellulose particles instead of submicroscopic micellae. The swelling of the membrane leads to a separation of the particles, but the spaces between them are filled not with water alone but with swollen cementing substance.

### Cellulose Particles and Macromolecules

Future research, in these fields, presents no more important problem than that of the origin and nature of the cellulose particle itself. Although it apparently reacts as a unit in the various optical and microchemical tests which have been applied to it, there is no reason, upon the basis of present information to assume that it is made up entirely of cellulose. Special methods are now being worked out in an attempt to answer this question. Until this is known any reference to the cellulose particle as a "giant molecule" and any description of it in the sense of the "macromolecules" in proteins and certain organic substances other than cellulose, are obviously unwarranted.

### Conclusion

In conclusion it must be emphasized that the data presented concerns cellulose membrane formation and not cellulose formation. Our observations have furnished no information concerning the origin of the cellulose itself from the extremely complicated chemical and physical relationships of the living protoplasm. When first identified it is in the form of the cellulose particle. Nor have we any basis at present for applying these data to the presumably more complex lignified and suberized plant cell membranes. Observations by Ritter (*10*), upon the minute structure of the cell wall of wood fibers, are undoubtedly suggestive in this connection. Since, in biological material, an understanding of the properties of an adult form are very frequently obtained only through a detailed study of its progressive stages of growth, it is more than probable that a careful study of the developing wood cell represents the proper approach to the problem of the chemical and physical relationships of the cellulose, lignin, pectin, etc., in these membranes.

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# Color Analysis and Specification*

By Joseph Razek[1]

**Abstract**

*A general outline of the spectrophotometric method of color analysis is given followed by the method of reduction to trilinear coordinates in accordance with the procedure suggested by the International Committee on Illumination in 1931. Calculation and significance of dominant wave length, colorimetric purity and relative brightness are discussed and a sample calculation given. In the case of white samples, a further calculation from the trilinear coordinates makes possible the calculation of "whiteness" in accordance with Judd's formula.*

Inspection of the recent programs of the annual meetings of the Technical Association of the Pulp and Paper Industry reveals the fact that practically every program included one or more papers dealing with the subject of color measurement. The importance of this subject to the paper technologist is immediately obvious, all the more so, since within recent years the tendency has been toward definite numerical determination and specification of the many variables dealt with in the paper industry. The writer has had occasion to discuss this subject with technical men in most of the fields in which color is at all important and the outstanding fact has been that among paper technologists the knowledge of the subject is more definite and exact than among those of any other field. Nevertheless, at the risk of repeating what many of you have heard on numerous occasions, a general summary of the principles of modern color analysis and specification based on spectrophotometric analyses will be given.

## Principles of Color Analysis

The subject of color has been of considerable interest to physicists and psychologists for many years. In fact, as early as the seventeenth century Sir Isaac Newton devoted some attention to it, and about seventy years ago, Clerk Maxwell, the great mathematical physicist, made important contributions. The activity of the scientists was noticed by technical men, and many instruments, based on the various findings, were devised for the measurement of color. While most of these instruments were sound in principle as far as they went, the majority of them either required skill on the part of the operator such as is only rarely found, or gave results depending entirely upon instrumental constants, lacking universal applicability.

In order to understand the various phases of the subject, let us examine just what happens when we look upon a colored object. Suppose we are looking upon a blue card held in daylight. A simple and well known experiment will show that daylight which we call "white" light is actually made up of many colors ranging from deep violet, through blue, green, yellow, orange and red. The proportion of each of these which happens to be present gives to the combination those properties which we have learned to associate with daylight. The same components are present in the other sources of white light such as incandescent lamp light, but in different proportions. The blue card which has all the component colors falling upon it will reflect some of all the components, but it will reflect the blue component of the white light to a greater degree than it will reflect the other components. This will result in a change in the relative proportions in the light reflected from the card. The portion of the originally white light reflected from the card will be richer in the blue component relative to the others, and when this light of altered composition enters the eye of the observer, he will interpret the color as "blue." Other colors will be present in the light entering the observer's eye, often in quite large proportion, but if the one component is enriched in proportion to the others, the color of that component will be assigned to the object. If an object reflects all the component colors in about the same ratio, such an object is characterized as "gray," or "achromatic."

From this we see that the color of an opaque object, as interpreted by an observer, involves three independent factors. First: the character of the illuminating source will determine the color sensation which the observer experiences. Obviously an opaque sample can only reflect, to a greater or less degree, the light which falls upon it. (This neglects the case of fluorescence, with which we are not concerned in the case of most substances). However, the common "white" sources contain the same components, although in different proportions, and so in a general way, the color assigned to a given object will be the same under the usual types of illumination. Second: the color which the observer assigns to the object is affected by the selective reflecting power of the object to the various component colors. That is, a blue sample will reflect more of the blue light than it will reflect the green, yellow and red, whereas, a red sample will absorb a greater portion of the blue, green and yellow, and in turn reflect a greater portion of the red light. This selective reflection is the physical quantity which determines the color which is assigned to an object. Third: the responsiveness of the visual mechanism of the observer to the various colors will determine the sensation which he will experience. But this quantity is entirely subjective and can be evaluated only indirectly, if at all. Just what any individual sees, when he looks at a "blue" card, only that individual himself knows, and it is utterly impossible for him to convey his impression to another. The individual has simply learned to associate a certain visual sensation with "blue" and when he experiences that sensation, he interprets the stimulus as "blue."

Any fundamentally correct method of color specification must recognize these three factors, and in fact, this has been done. The second of the three factors is concerned with a physical property of the sample itself, and this will be discussed first. To obtain the actual amount of light of each color reflected from the sample in absolute units would be quite difficult and really unnecessary. Instead, the amount of light reflected from the sample relative to the amount of the same color reflected from some standard substance is sufficient, and much easier to determine. Some substance, which is generally known as "white," such as magnesium carbonate, or better, magnesium oxide, is taken as the reference standard. The latter is found to reflect about as high a percentage of the incident light as any known substance and is practically non-selective, that is, it reflects all colors equally well.

To obtain a color analysis, a certain amount of light of a definite color, say violet, is allowed to fall upon the standard and the amount reflected from the standard is

* Presented at the fall meeting of the Technical Association of the Pulp and Paper Industry, Ambassador Hotel, Atlantic City, N. J., Sept. 18-21, 1935.

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determined. The standard is then replaced by the unknown sample, and the same amount of violet light allowed to fall upon it. The amount of violet light reflected from the unknown sample will be less than the amount reflected from the standard, and the ratio of the two amounts of light is known as the "reflectance" or "reflection factor." This experiment is repeated for all the component colors of white light, and the reflectance determined at each of the colors. A curve connecting the reflectance and the color of the incident light is known as a reflectance curve. In the case of transparent samples, the procedure is exactly the same, except that the light transmitted by the sample is measured, instead of the light reflected from the sample.

But merely stating the component colors by name, such as violet, blue, green, etc., would not be sufficient for any precise numerical specification, and it is necessary to assign definite numerical values to the component colors. If we pass the white light through a glass prism, we find that it is broken up into a continuous gradation of colors ranging from the violet to the red, and while there seem to be localized bands of one color, on closer inspection it will be found that the colors merge into one another by imperceptible degrees. When light from an incandescent gas, such as that obtained from the gaseous tube signs, is passed through the prism instead of white light, we find not a uniform gradation of colors, but a relatively few bright lines, each color occupying identically the same position as the corresponding color in the case of the white light. Physicists have studied these bright lines for many years and find that a precise number which corresponds to the wave length of the radiation can be assigned to each line. The same number can then be assigned to that part of the continuous array obtained with white light. The wave lengths are found to be extremely small, and in colorimetry, are usually stated in millimicrons, which are ten-millionths of a centimeter. Thus it is found that violet corresponds to a wave length of approximately 450 millimicrons, blue, 500, green, 550, yellow, 580, orange, 600, and red, 630. The limits of the visible colors run from about 400 millimicrons to about 700 millimicrons, the exact limits varying slightly for different individuals. The continuous array of color ranging from the violet to the red, formed when white light is passed through a prism is known as the continuous visible spectrum, and any point in this spectrum, and hence any spectral color can be definitely specified by merely giving the wave length associated with it. Thus, the bright green line obtained when a light of a mercury arc is passed through a prism has a wave length of 546.1 millimicrons,, one of the bright violet lines, has a wave length of 435.8 millimicrons, etc.

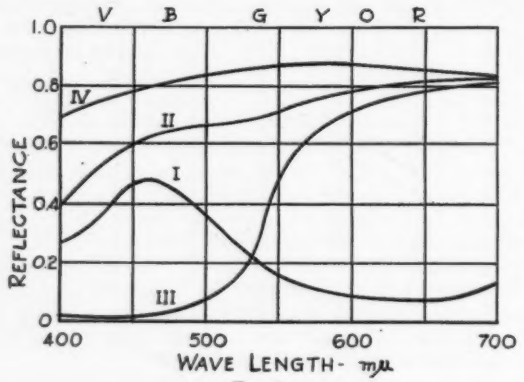


FIG. 1.

**Reflectance—wave length curves. I, A blue card. II, Newsprint. III, Yellow Pigment. IV, White Clay**

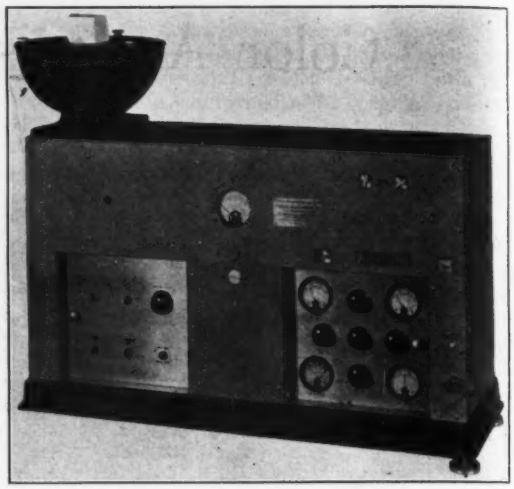

FIG. 2.

**The Razek-Mulder Color Analyzer, an automatic photoelectric Spectrophotometer.**

### Wave Lengths vs. Color Names

Using wave lengths as the base upon which the reflectance curve is drawn, instead of the general color names, we can make a precise plot of the curve of the reflectance-wave length relation, which is the exact statement of the physical color of an object. Fig. 1, shows four reflectance curves. Curve I is that of a blue card, curve II, a sample of newsprint, curve III, a yellow pigment, and curve IV, a white clay. On this curve, the standard white magnesium oxide would plot as a horizontal line at 1.0. Two points should be noted on these curves. The sample of newsprint, curve II, actually reflected a greater percentage of the blue light which fell upon it than the blue card, and more red and yellow light than the yellow pigment. But since the selection in favor of any color was not very great, the sample would be interpreted as nearly white. Also, both the blue card, and the yellow pigment reflect a small amount of all the colors. No opaque object is completely absorbing for any color.

Instruments for obtaining the data from which the reflectance curves are plotted are known as spectrophotometers, or more popularly, color analyzers. Visually operated instruments in which the operator is called upon to match two halves of a field, have been available for many years. More recently, automatic instruments, making use of photoelectric cells and vacuum tube amplifiers, have been developed, which require much less skill on the part of the operator. The recording automatic color analyzer developed by A. C. Hardy at the Massachusetts Institute of Technology, and the Razek-Mulder Color Analyzer, Fig. 2, developed by P. J. Mulder and the writer at the University of Pennsylvania are the best known examples of the automatic type instruments. (*1, 2*). Descriptions of the latter instrument have been given before the Technical Association on several occasions, and will not be repeated here. However, it may be of interest to note that one of our instruments has been in successful use in a pulp mill for over two and one half years. (*3*).

Except for gloss or other surface effects, the reflectance-wave length curve gives the complete story as to the *physical* color of the sample under consideration. The curve contains within itself and implies everything that we want to know about the color but the information contained in it must be interpreted. If two samples have identical reflectance curves, they will appear the same un-

der any and all forms of illumination and to any and all observers. (Again neglecting differences due to surface structure). But it is quite possible that two samples will have slightly different reflectance curves and still appear identical under some types of illumination. It is therefore necessary to devise some means of reducing and interpreting the reflectance curves in terms of quantities which will more readily express the actual visual differences.

Since the reflectance curve is to be reduced to quantities which are significant visually, it is necessary to include factors based upon the spectral quality of the illuminating source and upon the response of the observer to color stimuli. But both these factors are subject to wide variation, and in order that the data obtained may be universally applicable, standards according to which the reductions are to be made, were established by the International Committee on Illumination in 1931. (*4*).

It is well known that the sensation evoked by a colored object can be duplicated by a mixture of three primary colors in some definite proportions. Furthermore, any three colors can be used as the primaries, provided only that no two can form the third. It would seem reasonable, therefore, to take the percentage of each of the three specified primaries which must be combined to give the same sensation as the sample under test, to represent the specification of the color. The primaries ordinarily used are red, green and violet, but when these are used certain colors will require negative amounts of one of the components. This difficulty can be avoided, and other advantages secured, by making certain mathematical transformations, which in effect, sets up imaginary primaries. Since the experiment of combining the primaries to give the same sensation as the sample under test is never performed, no disadvantage results from this procedure. Hence, if two colors are each matched by the same amounts of the respective primaries, they will appear the same, even though the reflectance curves differ somewhat. The relative amounts of each of the primaries give three numbers which are known as the "trilinear coordinates" of the color. The actual amount of each of the primaries required for the color match is determined by the "relative brightness" of the sample. By the special way in which the primaries were chosen, the numerical value of the relative brightness, or "reflectivity" is made the same as the amount of one of the primaries, except for the location of the decimal point.

### Illumination and the Observer

It has been pointed out that the visual appearance of a sample depends upon the illuminating source. In practice, the character of the illuminant varies within wide limits,

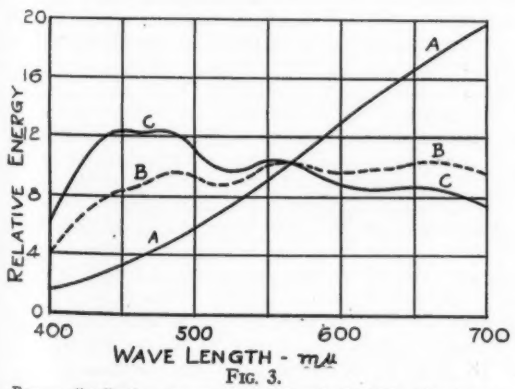


FIG. 3.

Energy distribution curves of the Standard I.C.I. Illuminants.

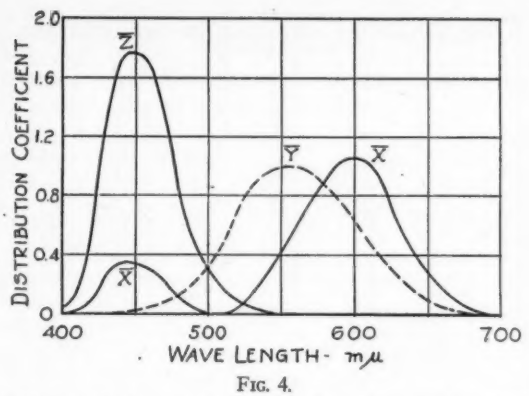


FIG. 4.

Tristimulus specifications of spectrum stimuli, according to the 1931 I.C.I. Standard Observer and Coordinate System.

and here again it was necessary to make a definite specification. The three common sources of illumination are daylight, sunlight, and incandescent lamp light. Even these three vary, the former two with latitude, time of day and year, weather, and the latter, with the condition of the lamp, voltage, etc. To eliminate the effect of these unavoidable variations, the International Committee on Illumination (I. C. I.) has specified the spectral character of three illuminants, known as "A," "B," and "C," which are respectively, a specified type of incandescent lamp operated at a specified temperature, a laboratory approximation to average sunlight, and a laboratory approximation to daylight. These laboratory approximations to the natural sources are used because of their ready reproducibility in a properly equipped laboratory. Spectral curves of the three illuminants are given in Fig. 3.

While there is a general similarity in the visual response of most observers, perfect identity would not be attained. This would result in the failure of the two observers to agree as to the proportions in which the three primaries must be taken to obtain a color match with the unknown sample. To eliminate this difficulty, the I. C. I. has in effect, specified a hypothetical observer, to whom all the observations are referred. This is accomplished by giving the relative amounts of the selected primaries which this observer would take to match the visible spectrum, point by point. The values for any real observer would not differ greatly from those for the standard observer, since the standard values were actually obtained as the average of a number of actual observers. The three curves shown in Fig. 4, are the relative amounts of the primaries, $\bar{x}$, $\bar{y}$, and $\bar{z}$, which the standard observer would need to match any given wave length in the visible spectrum. *In a very rough way,* these three primaries correspond to the red, green, and violet respectively.

Since the visual appearance of a sample may also vary with the angle of viewing and observing, the I. C. I. has also set up definite specifications for this factor. This variable is probably of less importance in the case of smooth homogeneous materials such as paper than in the case of materials which show a strong structure such as textiles. In any case, the instruments used in determining the spectrophotometric curve are designed with a view to satisfying, as far as possible, the set specifications.

In effect, therefore, the method of color specification is this: The standard observer looks upon the sample under study illuminated by one of the standard illuminants. He proceeds to make a color match by mixing the three primaries in the form of colored lights and shining this mixture upon the standard white magnesium oxide surface.

TABLE I.
COMPUTATION OF TRILINEAR COORDINATES AND REFLECTIVITY.

| Wave Length | $\bar{x}E$ | $\bar{y}E$ | $\bar{z}E$ | R | $\bar{x}ER$ | $\bar{y}ER$ | $\bar{z}ER$ |
|---|---|---|---|---|---|---|---|
| 380 | 4 | ..... | 20 | .... | ..... | ..... | ..... |
| 90 | 19 | ..... | 89 | .... | ..... | ..... | ..... |
| 400 | 85 | 2 | 404 | 0.396 | 34 | 0 | 160 |
| 10 | 329 | 9 | 1570 | .434 | 143 | 4 | 681 |
| 20 | 1238 | 37 | 5949 | .483 | 598 | 18 | 2873 |
| 30 | 2997 | 122 | 14628 | .530 | 1588 | 65 | 7753 |
| 40 | 3975 | 262 | 19938 | .567 | 2254 | 148 | 11305 |
| 450 | 3915 | 443 | 20638 | .594 | 2325 | 263 | 12259 |
| 60 | 3362 | 694 | 19299 | .615 | 2068 | 427 | 11869 |
| 70 | 2272 | 1058 | 14972 | .632 | 1436 | 669 | 9462 |
| 80 | 1112 | 1618 | 9461 | .646 | 718 | 1045 | 6112 |
| 90 | 363 | 2358 | 5274 | .657 | 238 | 1549 | 3465 |
| 500 | 52 | 3401 | 2864 | .667 | 35 | 2268 | 1910 |
| 10 | 89 | 4833 | 1520 | .675 | 60 | 3262 | 1026 |
| 20 | 576 | 6462 | 712 | .682 | 393 | 4407 | 486 |
| 30 | 1523 | 7934 | 388 | .689 | 1049 | 5467 | 267 |
| 40 | 2785 | 9149 | 195 | .698 | 1944 | 6386 | 136 |
| 550 | 4282 | 9832 | 86 | .709 | 3036 | 6971 | 61 |
| 60 | 5880 | 9841 | 39 | .726 | 3681 | 7145 | 28 |
| 70 | 7322 | 9147 | 20 | .742 | 4701 | 6787 | 15 |
| 80 | 8417 | 7992 | 16 | .758 | 6380 | 6058 | 12 |
| 90 | 8984 | 6627 | 10 | .770 | 6918 | 5103 | 8 |
| 600 | 8949 | 5316 | 7 | .780 | 6980 | 4146 | 5 |
| 10 | 8325 | 4176 | 2 | .789 | 6568 | 3295 | 1 |
| 20 | 7070 | 3153 | 2 | .796 | 5628 | 2510 | 1 |
| 30 | 5309 | 2190 | ..... | .801 | 4253 | 1754 | ..... |
| 40 | 3693 | 1443 | ..... | .804 | 2969 | 1160 | ..... |
| 650 | 2349 | 886 | ..... | .808 | 1898 | 716 | ..... |
| 60 | 1361 | 504 | ..... | .816 | 1111 | 411 | ..... |
| 70 | 708 | 259 | ..... | .823 | 583 | 213 | ..... |
| 80 | 369 | 134 | ..... | .828 | 306 | 111 | ..... |
| 90 | 171 | 62 | ..... | .832 | 142 | 52 | ..... |
| 700 | 82 | 29 | ..... | .834 | 68 | 24 | ..... |
| 10 | 39 | 14 | ..... | .... | ..... | ..... | ..... |
| 20 | 19 | 6 | ..... | .837 | 62 | 23 | ..... |
| 30 | 8 | 3 | ..... | Extrapolated | ..... | ..... | ..... |
| 40 | 4 | 2 | ..... | .... | ..... | ..... | ..... |
| 750-770 | 4 | 2 | ..... | .... | ..... | ..... | ..... |
| SUMS | 98041 | 100000 | 118103 | .... | 70167 | 72457 | 69895 |

$x_w$, $y_w$, $z_w$ 0.31012, 0.31631, 0.37357 — x, y, z, 0.33017, 0.34094, 0.32889

The relative amounts of each of the primaries required will be the trilinear coordinates of the color. In addition, the brightness or reflectivity of the unknown relative to the standard white will be numerically equal to the amount of the "$\bar{y}$" primary. Of course, the experiment is never performed, since the results can be more readily obtained by calculation from the spectrophotoelectric curve.

To illustrate the method of calculation, the trilinear coordinates are determined for the newsprint sample shown in curve II, of Fig. 1, and given in Table I. The form and values of the quantities used are taken from a paper by D. B. Judd. (*5*). The first column gives the wave lengths from 380 to 770 millimicrons in steps of 10 millimicrons. The next three columns headed $\bar{x}E$, $\bar{y}E$, and $\bar{z}E$, are respectively the products of the tristimulus specification of the pure spectrum for the standard observer, given in Fig. 4, and the energy distribution of I. C. I. illuminant "C," given in Fig. 3. The column headed R is the reflectance of the sample obtained from a spectrophotometric test of the sample made upon a Razek-Mulder color analyzer. At each wave length, the reflectance is multiplied successively by each of the three products, giving the three columns, headed $\bar{x}ER$, $\bar{y}ER$, and $\bar{z}ER$. The sum of each of the last three columns is obtained, and the ratio of each sum, to the total sum gives the trilinear coordinates. The sum of the column $\bar{y}ER$ is proportional to the relative brightness or reflectivity. Thus for the sample illustrated, the trilinear coordinates, x, y, and z are respectively, 0.3302, 0.3409, and 0,3289, and the relative brightness is 0.7246.

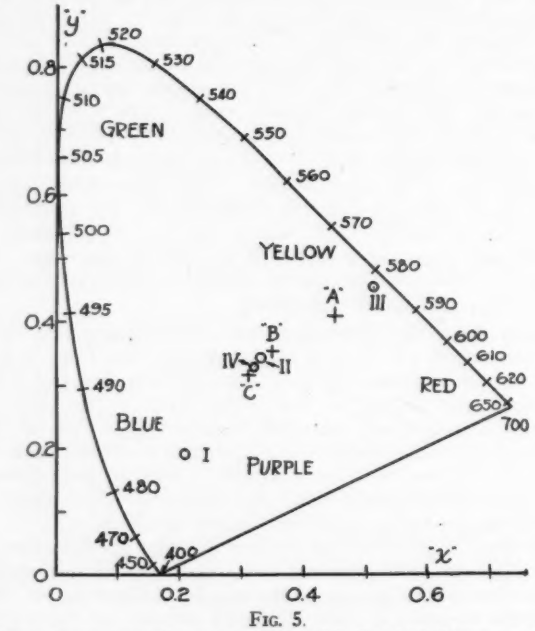


FIG. 5.

**Mixture diagram according to the 1931 I.C.I. Standard Observer and Coordinate System. Points plotted correspondent to the I.C.I. Illuminants and curves of Fig. 1.**

The trilinear coordinates can be plotted very conveniently upon the "mixture diagram" shown in Fig. 5. This diagram is based upon the Maxwell triangle with the equilateral triangle changed to a right triangle to facilitate plotting. Since the sum of x, y, and z for any color add up to 1.00, it is only necessary to plot any two of the coordinates, with x and y, being the usual choice. The curved line represents the locus of the pure spectrum colors, with the corresponding wave lengths marked upon the diagram. The three points marked "A," "B" and "C" are the points corresponding to the three standard I. C. I. illuminants. The other points marked I, to IV, are the points corresponding to the samples whose reflectances are given in Fig. 1.

All possible colors will plot inside the spectrum locus and the line joining its ends. The nearer a color plots to this locus, the more saturated it is. The achromatic colors, that is the whites, and grays, will plot near to the corresponding illuminant which is used in the calculation. It must be noted that the mixture diagram shows only the chromaticity of the sample, and does not include the relative brightness. For example, a perfect gray having a reflectance of exactly 0.5 throughout the spectrum, and the standard white having a reflectance of 1.0 throughout the spectrum, would both plot at the point corresponding to the selected illuminant. This is true since x, y, and z, are merely ratios, and always add up to 1.0. The reflectivity or relative brightness, on the other hand, does not show up on the mixture diagram, and depends upon the amount of energy actually reflected from the sample. The relative distance between two points upon the mixture diagram is a measure of the chromaticity difference in the two samples, although the scale is not the same in all parts of the triangle. Another mixture diagram whose points can be readily calculated from those of the I. C. I. triangle in which the scale of chromaticity difference is the same in all parts has been described by D. B. Judd. (*6*).

### Dominant Wave Length and Colorimetric Purity

Another specification of color which is quite significant is the dominant wave length and colorimetric purity. The dominant wave length is the wave length of the pure spectrum color which must be additively combined with the illuminant selected to give the color to be specified. The ratio of the brightness of the spectrum color to the total brightness of the combination is the colorimetric purity. The dominant wave length can be obtained from the diagram of Fig. 5, by noting the intersection of the line through the point representing the color and the point rep-

resenting the heterogeneous stimulus (generally one of the illuminants) and the spectrum locus. While the dominant wave length can be obtained approximately from the diagram, a much closer value is obtained when the wave length at the intersection with the spectrum locus is calculated. Since the colorimetric purity must be calculated in any case, very little additional effort is necessary to calculate the dominant wave length. Complete forms and tables for making these calculations are also given in Dr. Judd's paper referred to above. (*5*). The dominant wave length and colorimetric purity for the four samples

TABLE II

| Curve No. | Trilinear Coordinates I.C.I. x | y | z | Reflectivity Ill. "C" | Dominant Wave Length | Heter. Stimulus I.C.I. | Colorimetric Purity |
|---|---|---|---|---|---|---|---|
| I | 0.1905 | 0.2080 | 0.6015 | 0.176 | 479.8 | "A" | 0.452 |
| II | .3302 | .3409 | .3289 | .725 | 574.8 | "C" | .184 |
| III | .5104 | .4536 | .0360 | .465 | 582.8 | "C" | .938 |
| IV | .3174 | .3282 | .3544 | .861 | 571.0 | "C" | .086 |

whose reflectance curves are given in Fig. 1, are tabulated in Table II. Thus, for example, the yellow pigment, curve III, is found to have a dominant wave length of 582.8 and a colorimetric purity of 0.938 based upon illuminant "C." This means that the standard observer would find a chromaticity match between the yellow pigment illuminated by illuminant "C" (daylight) and a mixture of pure light of wave length 582.8 and light from illuminant "C" in the ratio of 0.938 and 0.062.

The paper industry deals to a great extent with nearly white samples and some special attention should be given to these. When a nearly white sample is subjected to visual examination, there is a tendency to average together the two separate factors of chromaticity and reflectivity. Empirically, this method of averaging the two factors was determined by correlating the ratings given to a number of nearly white paper samples by experienced graders with the reflectivity and the distance on a mixture triangle between the point representing the sample and the standard white. A simple formula for "whiteness" based on this work was recently announced by D. B. Judd. (*7*). The mixture diagram used not the I. C. I. diagram of Fig. 5, but the uniform chromaticity scale triangle. (*6*). The conversion of the results of the calculations made for the I. C. I. triangle to the r, g, and b for the equal step triangle is readily accomplished by means of three formulas given in the paper. (*6*). The use of the whiteness formula therefore requires only a few additional calculations after the I. C. I. trilinear coordinates are obtained.

Inspection of the whiteness formula will show that the formula gives real values only for samples whose departure from the magnesium oxide is quite small. Furthermore, the allowable departure increases with reflectivity. This is in accordance with the observation that a sample can show a greater selective reflection and still be generally classified as "white" when the sample shows a high reflectivity. The allowable chromatic departure narrows down very rapidly as the reflectivity drops.

All the foregoing calculations may seem very complicated but on careful study, it will be found that they are quite simple to perform. With the tables and forms given in the various papers referred to, the calculations are reduced to simple operations, readily performed by means of a calculating machine. The writer has in preparation a system for arranging the work to reduce the calculations simply to a series of additions. In this way the computations can be performed upon an ordinary adding machine such as is found in most offices. Attention should be called to the fact that the only truly physical measurement made upon the sample was the determination of the spectrophotometric curve. All the subsequent calculations were made necessary by the need for reducing the reflectance curve to more compact form so that the information implied in the curve, can be more readily grasped and visualized.

Much work has been done and effort expended by those who have been engaged in extending the use of the spectrophotometric method of color analysis and specification in industry. While these efforts have been received quite favorably by the industry, they are by no means as widely used as they deserve. The technical men of the industry will have to expend some effort to master the general ideas underlying the methods, and their principals will have to spend some money to take advantage of the work. But, as matters stand, the amount of money which need be spent to make adequate use of this work is quite small. It is hoped that this paper will help to introduce these ideas to those of the paper and pulp industry who can make the best use of them.

(Note: The various terms such as "light," "color," etc., were used in this paper in the usual popular sense. The Colorimetry Report of the Optical Society of America, which will be published in the near future, will contain critical definitions for the terms to be used in colorimetric specifications.)

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# Tolerances in White Water Losses*

By C. M. Baker[1]


### Abstract

*Standards or objectives limiting losses, toward which to work in white water utilization, are desirable. Adoption of arbitrary standards by state officials limiting stream pollution is not feasible because of variations in grades and operating conditions in the mill, and in stream characteristics and requirements, but limiting values might be adopted beyond which a mill should show cause why better operation should not be secured.*


Tolerances in white water losses! What do we mean? Tolerance on the part of the mill executives regarding wastes through the sewers, of the superintendent in the pressure brought upon him by advocates of white water utilization, or on the part of state officials and other advocates of stream improvement? Really, much tolerance is required in handling this problem of white water losses.

Inquiries are frequently made regarding the amount of water necessary in manufacturing various grades of paper, also with reference to permissible stock losses. What is good and what is poor operation in reference to wastes through the mill sewers? Should TAPPI adopt standards for white water losses indicative of

1. Excellent operation as an objective toward which to work.

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TABLE I
MILL WASTES REPORTED

| Gal. per Ton Prod. | Per Cent Loss in Suspended Solids: Volatile | Fixed | Total | Per cent Soluble |
|---|---|---|---|---|
| | Sulphite Pulp | | | |
| 20,900 | 1.24 | .04 | 1.28 | 121.96 |
| 43,460 | 1.57 | .10 | 1.67 | 114.11 |
| 45,500 | 1.37 | ..... | 1.37 | ..... |
| 1,800 | .60 | ..... | .60 | ..... |
| | Bleach Plant | | | |
| 39,000 | .40 | ..... | .40 | ..... |
| | Kraft Pulp and Paper | | | |
| 32,000 | 1.20 | ..... | 1.20 | ..... |
| | Ground Wood | | | |
| 15,620 | .08 | ..... | .08 | ..... |
| | Book | | | |
| 4,700 | .76 | .37 | 1.13 | .85 |
| 12,470 | .78 | 2.33 | 1.11 | 1.66 |
| 10,630 | .63 | 1.03 | 1.66 | 1.50 |
| 48,000 | 1.86 | .66 | 2.52 | 16.07 |
| 14,000 | 1.38 | 4.38 | 5.76 | 3.31 |
| 14,200 | 1.17 | .55 | 1.72 | 1.33 |
| 13,400 | 1.09 | 1.80 | 2.89 | 1.53 |
| 11,000 | .70 | 2.62 | 3.32 | 4.47 |
| | News | | | |
| 29,700 | 1.27 | ..... | 1.27 | ..... |
| | Tissue | | | |
| 67,380 | .94 | ..... | .94 | 7.20 |
| 26,370 | .44 | ..... | .44 | 9.69 |
| 22,050 | .99 | .01 | 1.00 | 5.52 |
| 7,014 | .70 | ..... | .70 | ..... |
| 18,500 | .93 | ..... | .93 | ..... |
| | Writing | | | |
| 32,900 | 1.01 | .02 | 1.03 | 3.63 |
| | Board | | | |
| 2,144 | .40 | ..... | .40 | ..... |
| 6,000 | .60 | ..... | .60 | ..... |
| 22,500 | 1.90 | ..... | 1.90 | ..... |
| 8,514 | 1.15 | .30 | 1.45 | .25 |

2. Tolerant operation, losses in excess of which indicate carelessness and poor control; a standard that every mill should attain except possibly under very unusual operating conditions.

A factor which the industry must confront is the movement on the part of various state departments dealing with stream pollution to adopt and require certain standards in regard to industrial wastes. Two states at least have considered the question of adopting standards with reference to permissible stock losses or total suspended solids from paper mill wastes. This problem is a live issue, and whether the industry likes it or not, sooner or later certain definite requirements will be made in regard to the discharge of wastes into our streams. Shall we adopt our own standards or have them forced upon us?

### Suggested Standards

In 1930 a communication was distributed to members of the American Paper and Pulp Association by the writer in which it was pointed out that the water consumption in a paper mill should be reduced to less than 20,000 gallons per ton of product and the fiber loss to less than 1 per cent of production. There has been no occasion to change this conclusion except possibly in the methods of operation.

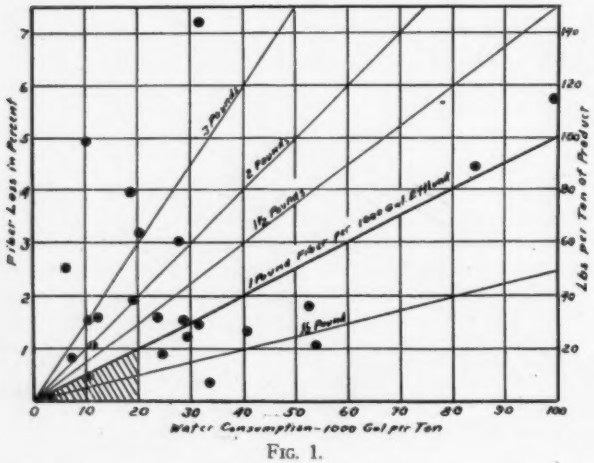


FIG. 1.

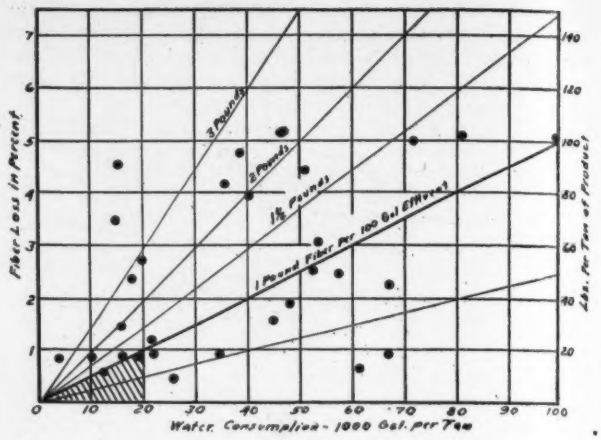
Fiber Loss in Percent
Lbs. per Ton of Product
Water Consumption - 1000 Gal. per Ton
3 Pounds
2 Pounds
1½ Pounds
1 Pound Fiber per 100 Gal Effluent

FIG. 2.

The communication follows:

"WATER CONSUMPTION AND FIBER LOSSES

"Data from 24 paper mills have been plotted on the diagram (Fig. 1) showing the relation of water consumption to fiber losses.

"Efficient savealls will reduce the fiber loss to less than one pound per thousand gallons of effluent.

"Conservation in water consumption and white water utilization will reduce the volume of waste to less than 20,000 gallons per ton of product.

"On this basis, the actual fiber loss through the sewers should not exceed 20 pounds per ton of product, or 1 per cent. All mills would then fall within the shaded area in the lower lefthand corner of the diagram, but only two of those plotted actually fall within this area. Five, however, show losses less than 1 per cent and 16 less than 2 per cent.

"If the plotted data for your mill falls below the one-pound-fiber-loss line, you can eliminate much loss by simply reducing your water consumption. But if your data falls above that line, reducing water consumption alone is not enough; you must take further steps such as installing savealls and recirculating white water."

A similar plotting of substantially the same group of mills for 1934 is indicated in Fig. 2. It will be observed that whereas in 1930 there were only five mills below the 1 per cent loss, there are now 10, but the number remains the same, 10, for those with a water consumption of less than 20,000 gallons per ton. This is not a very good showing. More mills should be under the 1 per cent loss, although short runs caused by economic stress is probably a contributing factor to this lack of progress.

Present day practice by some of the better operated mills is indicated in the accompanying Table I. This tabulation is not as extensive as is desirable, but is indicative of what may be accomplished.

It will be observed that there is not a material difference in fiber loss in the different grades. The high filler or fixed suspended solids loss in the book group, however, is significant and suggests the desirability of setting up separate standards for fiber and filler losses. Soluble losses are indicative of certain stock losses but their interpretation is not specific and sufficient data are not available to warrant suggesting standards.

Based upon the data available, and experience in the field, the writer suggests the standards in Table II "Tolerant Losses" for fiber loss and fresh water required in processing indicating.

1. Excellent, an objective toward which to work, and
2. Tolerant, losses in excess of which indicates careless operation and poor control.

TABLE II
TOLERANT LOSSES

| Class | F.W. Gal. per Ton: Excellent | Tolerant | Per Cent Fiber Loss: Excellent | Tolerant |
|---|---|---|---|---|
| Pulp Mill, Unbleached | 20,000 | 30,000 | 1.00 | 1.75 |
| Pulp Mill, Bleached | 25,000 | 40,000 | 1.25 | 2.00 |
| Paper Mill (no stock washing) | 10,000 | 20,000 | 1.00 | 1.75 |
| Pulp (unbleached) and Paper | 25,000 | 35,000 | 1.50 | 2.25 |
| Pulp (bleached) and Paper | 30,000 | 45,000 | 1.75 | 2.50 |
| Paperboard | 3,000 | 6,000 | .75 | 1.25 |
| Book Mills, Filler Loss in per cent of Filler Furnish | | | 20.00 | 30.00 |

### Relation of Clay Furnish to Loss

Clay or filler retention in book paper ranged from 20 per cent with all fresh water to 80 per cent with a substantially closed white water system in tests made a few years ago at the Forest Products Laboratory regarding the use of white water in book papers. These tests indicated no deleterious effects upon the paper providing adjustments were made in the furnish to compensate for the filler returned with the white water. The filler losses, in per cent of production, for variations in per cent filler furnish and retention, also for variations in volume of waste and pounds of filler per thousand gallons, are indicated in Fig. 3.

Assume that a book mill has a furnish consisting of 20 per cent clay with 60 per cent retention of this clay in the finished sheet, (equivalent to 12 per cent in the sheet). The intersection of these two lines on the diagram at "A" shows an 8 per cent loss based upon the total production. If the clay content in the mill waste is 5 pounds per thousand gallons following this line to the intersection of the 6 per cent loss in the effluent at "B," shows the total waste to be 24,000 gallons per ton of product. If this volume of waste is reduced to 10,000 gallons and the concentration remains the same, 5 pounds, the loss is reduced to about 2.3 per cent "C," which would require only 14.3 per cent furnish to secure the same loading in the finished sheet. This would be a retention of 84 per cent.

Likewise referring to Figs. 1 and 2 it will be observed that with a fiber loss of one-half pound per thousand gallons 40,000 gallons of waste per ton produces a 1 per cent loss and 100,000 gallons, 2½ per cent, while the concentration may be increased to 2 pounds per thousand gallons if the volume is reduced to 10,000 without exceeding the 1 per cent limit.

In general it may be stated that the stock losses in a mill are almost directly proportional to water consumption. Savealls reduce the losses to some extent, but unless the filtrates from the savealls are returned into the system effective white water utilization can not be developed.

#### Limiting Factors

Many mill operators will contend that no definite standards may be set up because each mill is an individual problem. Their product is a little different from any other; their conditions of operation unusual; so they cannot do what other mills are doing. Many of these difficulties are more imaginary than real. Nevertheless there are certain factors that have definite bearing upon the problem.

### Short Runs

Short runs probably constitute the most difficult problem in arriving at any definite conclusions regarding white water losses. This is particularly true when coupled with long beating time. To illustrate: a mill is making four changes a day with six hours' beating time required. It is thus necessary to start beating the stock for the next run at least six hours before the preceding run is completed so that, if the color on the machine is different, it is impossible to furnish and drop beaters with the white water available. Arrangement of color runs in proper sequence of shades, however, sometimes permits running from one color into another.

Clean-ups at the end of runs are not so important a

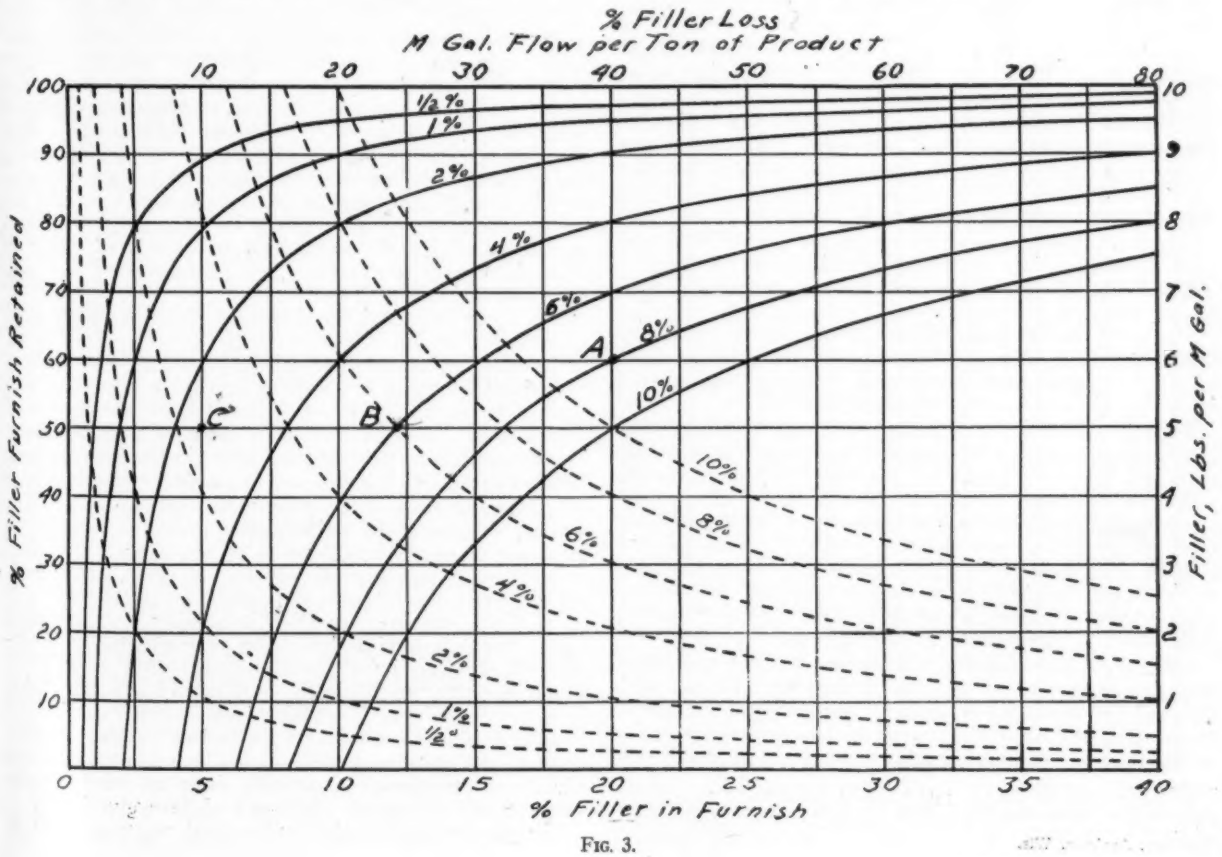


Fig. 3.

factor. A waste of 500 gallons per minute from a paper machine carrying two pounds of stock per thousand gallons amounts to 1480 pounds of stock per day. Stored white water to equalize the demand may amount to 5000 gallons containing 5 pounds of stock per thousand gallons. A clean-up then would result in a waste of only 25 pounds of stock from this source. Loss from the chests and equipment should not exceed 50 pounds, or 200 gallons of 3 per cent stock, making a total of 75 for the clean-up. This would require 20 clean-ups a day to equal the continuous loss.

COLOR

Colors are primarily of importance in connection with short runs. Where the runs are long the color may be adjusted so as to compensate for returned white water. With short runs, however, this sometimes is not feasible.

FURNISH

Furnish must be modified. The sizing problem is different. Chemical adjustment of the white water may be necessary to facilitate sizing. Where papers are used for chemical processing in conversion the chemical characteristics may be so changed as to result in difficulty with the customer.

SHEET CHARACTERISTICS

Although the characteristics of the finished sheet have some bearing upon the problem, it is believed that in the majority of cases proper adjustment will secure satisfactory characteristics. One possible exeception is glassine paper. Experience has indicated that white water utilization tends to increase opacity, a desirable characteristic in most papers, but objectionable in connection with glassine.

# Colloidal Aspects of Cellulose*

By Ben W. Rowland[1]

**Abstract**

*A survey of recent work on selected topics concerning the colloidal behavior of cellulose as related to technical problems of paper making.*

The honor of an invitation to appear on this occasion has become inseparably associated with a sense of responsibility. Recent colloid research in the field of cellulose, stimulated by the textile and related industries, as well as that of paper, has perceptibly brought the complexities of cellulose behavior at least partially within the range of interpretation, and promises not only to supplement the older empiricism but to liberate entirely new and independent technical possibilities for the future. Competent reviews on the subject have recently become available [Lorenz *(17)*, Krüger *(15)*, Lorenz *(18)*], as well as extended treatment of special phases of the problem, notably with reference to hydration, [Katz *(12)*, Strachan *(29)*, Bell *(2)*, Campbell *(5)*, Simmonds *(28)*].

There is, in general, receptivity on the part of practical paper makers for any technical deduction, insofar as it is now possible, to be gleaned from the accumulating fundamental knowledge concerning their principal raw material. Perhaps the present occasion affords an opportunity to add appreciably to an interpretation of the colloidal characteristics of cellulose, and to anticipate, with appropriate reserve, the most promising applications.

Broadly speaking, it is helpful to regard cellulose as belonging to a group of biochemical materials, the physical, and to a certain extent, the chemical characteristics of which are not fixed, but subject to the natural changes of alteration, degradation and ultimate decay. In the present state of the art, we are almost completely unable to prevent or even resist these aging changes, as has been done, for example, in the rubber industry through the use of antioxidants. Progress along these lines may, with much confidence, be anticipated in the cellulose industry.

Among the most important of the natural aging changes in cellulose is that of gradual desiccation. In colloidal phraseology, this is the syneresis of the gelatinous cellulose fiber. That the moisture content and moisture equilibria of the fiber are of fundamental importance in practically every operation of the paper mill, as well as in the characteristics of the finished products, needs no emphasis. That the moisture content affects the physical properties of the fiber itself has been convincingly demonstrated by Peirce *(21)*. In common with biocolloids of its class, a cellulose fiber holds its moisture in two forms, a colloidal form intimately associated with the hexose elements and a hygroscopic form associated more particularly with capillarity. The former is present in very small amounts, is not readily responsive to humidity changes, cannot be removed quickly except at temperatures much in excess of the boiling point of water and without excessive and irreversible damage to the fiber. This colloidal water exerts a profound influence upon the physical properties of the fiber; its strength, rigidity, and swelling features and probably those of the finished sheet [Strachan *(30)*]. The capillary water, on the other hand, may vary between wide limits with humidity conditions and plays a lesser part in strength features but is of great importance in the paper making operation. There is probably a slow and partial equilibrium between these two kinds of water in cellulose and the processes of aging tend toward the complete loss of both.

It is common experience that pulp which has been dried at excessive temperatures or great dryness, loses some of its most valuable paper making qualities, the desiccation effects being only partially reversible beyond a certain point [Katz *(13)*]. Effort has been directed toward a restoration of moisture loss in damaged fiber and even an improvement in hydrating behavior in fresh fibers, [Schwalbe *(25)*]. To this end a specific effort has been noted among the simple sugars and amino acids. The work of Young in the writer's laboratory *(34)* shows the influence of pentosans. Doubtless the future will hold possibilities of aging inhibitors for cellulose, particularly for the lower cost types, and hydration accelerators. It is, in fact, within reasonable possibility that chemical rather than mechanical hydration may eventually be accomplished. We have noted certain types of sulphite which hydrate mechanically without visible fibrillation even to approximate a glassine stage. This may involve a rupture of the somewhat hypothetical Lüdtke envelope surrounding the fiber, [Weil *(32)*]. That this may eventually be accomplished chemically is prophesied by the work of von Weimarn *(33)* and of Haegglund *(7)*.

For the present much fundamental work remains to

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be done on the effects of extraneous matter on the hydration phenomenon. The work of Schwalbe and Fischer *(26)* on the effect of ions in swelling, particularly hydrogen-ions, as well as that of other investigators, Kanamaru *(11)*, and Hall *(8)*, indicates the possibility of an isoelectric point for cellulose as proposed by Kanamaru *(21)*, with its great theoretical significance in hydration. It is suggested that this isoelectric point is not normal to cellulose, but is only an apparent one due to traces of cellulosic transformations behaving as amphoteric electrolytes. Hydration, as understood by paper makers, may not be identified with colloidal hydration [Seborg and Stamm *(27)*] but in the normal hydration operation a certain response to moisture influence would appear to be essential [Kress and Bialkowsky *(14)*]; hence the general interest in swelling and its contributory factors. Applications of theoretical principles to the problem become doubly effective since the drying of the sheet involves many of the same phenomena in a reverse sense, and there is a growing accumulation of evidence that the general principles of swelling apply to cellulose [Lottermoser and Wilhelmi *(20)*].

Attention directed toward thermal changes associated with hydration further help to elucidate the basic mechanism. The swelling of cellulose is strongly exothermic [Katz *(13)*, Argue and Maass *(1)*]. Accordingly Lewis and Gilbertson *(16)* found the beating operation not only to proceed more rapidly at lower temperatures but also that better strength followed under such conditions. This might be interpreted in the sense that at lower temperatures swelling is favored and the moisture conditioning attains more nearly an optimum for the mechanical action of hydration, so that the action proceeds with less damage and in a shorter time.

Heats of swelling of cellulose, as well as velocity of swelling, are most fundamentally a property of minute colloidal structure. In our laboratory we have attempted precise measurements of velocity and extent of swelling using an improved procedure from that of Kress and Bialkowsky *(14)*. The experimental difficulties of such measurements on compressed cellulose pads such as we worked with (dilation due to spring back following the relaxation of strains in the compressed fibers) became serious but did not prevent our finding a complex although definite relation between total swelling, rates of swelling, and pulp strength. It is to be hoped that current work on heats of wetting will be greatly extended to afford a physical, rather than chemical means of pulp evaluation; the method would appear much better suited to precise measurements than is that of maximum swelling or rates of swelling. Measurements of swelling and heats of swelling made in the presence of small amounts of electrolytes should show relationships between structure and hydration behavior under paper making conditions, since it is now definite that cellulose as a gel responds in a general way to the ionic effects of the Hofmeister series. It may now be deduced that the astringent effect of trivalent aluminum ions, as well as of the divalent calcium and magnesium ions, even when present in low concentration as in hard water, will play a quite appreciable part in the water relationship toward cellulose, tending generally to be adverse toward hydration.

Superimposed upon their effect on the gel properties of cellulose, ions play a vital role in an electrostatic sense when present in pulp furnish. Because of its higher dielectric, water takes a positive charge in contact with cellulose, but the magnitude of the charge is not independent of the history and source as well as purity of the sample. The negative charge on cellulose against pure water may be neutralized and even made positive by alum [Briggs *(4)*]. Again the valence of the cation is important, although the anion is not without its effect.

Harrison *(9)* found, from a study of streaming potentials, that acids in general accord with colloidal effect increased the charge on positive fibers and decreased that of negative ones, bases acting oppositely. The general mechanism of swelling has been explained throughout the colloid literature in terms of the Donnan Equilibrium of unequal distribution of ions across a membrane of selective permeability. It is difficult to ascribe to cellulose proper the properties of a colloidal electrolyte or of amphoteric tendencies, and the presence of a membrane in the Donnan sense in the cellulose fiber structure is no more than theoretical at the present time. As a consequence, the hydration of cellulose would not appear to follow completely the osmotic theory of Loeb nor the parent theory of Donnan. The deviations would seem to lie in the specific affinity exhibited by cellulose for water quite independently of extraneous ion influence. But in the presence of electrolytes, the Donnan principle of the non-diffusible ion must somehow play an important part as may be deduced from the influence of ionic valence on electric mobility of very fine fibers as shown by Lottermoser *(19)*, where the non-cellulose constituents of fine wood fibers impart very clearly the characteristics of colloidal electrolytes to the fiber itself. Perhaps a simpler and more convenient theory of the swelling mechanism, such as the Tolman principle, will be preferred as a working hypothesis, referring the swelling to a general structural dilation as a consequence of an electric double layer lining at the many internal interfaces throughout a fiber, exerting a mutual repellent action and a distending effect, drawing water in.

Apart from the influences which these electrostatic conditions may exert on the physical condition of the cellulose itself, they play an essential role in the complex mechanism of many paper making phenomena. Accessory materials used in paper, such as starch, filler, rosin, and color, are retained in the sheet either through the processes of surface adsorption involving surface energy and electrostatics or (less desirably) through mechanical filtration. That a given set of conditions will fix the electrostatic condition on accessory materials as well as that of cellulose is certain; but their behavior toward the fiber is with equal certainty conditioned by the electrostatic atmosphere around the fiber. The delicate electrostatic balance between the various ingredients of a paper making furnish (including that very important positive colloid, aluminum oxide, always present) may shift disastrously with comparatively slight changes in pH, temperature, etc., and that this may give rise to the well known variations of certain sheet characteristics may afford a measure of consolation to the paper maker. The technical control of some of these vagaries through the expedient of larger and predominating effects is noted in the case of starch effects [Rowland *(24)*] and rosin sizing studies in the writer's laboratory, (patents pending). And it is precisely these hitherto uncontrolled variables that theoretical research may serve to circumvent.

The response of cellulose to its ionic environment involves selective ion adsorption. The consequences of this are responsible for the apparently paradoxical difference in pH between pulp and white water. The selective adsorption of alkali from neutral sodium chloride solution leaving the solution acid is a case of hydrolytic

adsorption and a phenomenon of great significance in the whole field of ion distribution within the beater furnish. Other cases may be cited of a pulp acid to its white water, illustrating the disturbing influence of such materials as aluminum oxide and its adsorption on the fibers. In the writer's laboratory Bialkowsky *(3)* found the alkali binding capacity of pulp to differ greatly with various pulps. Upon the theory (now quite generally held) that rosin sizing involves essentially free rosin in the sheet, it was noted that the hydrolytic adsorption of alkali by pulp from rosin soaps was generally in accord with sizing experience. In other words, a cellulose fiber is endowed with the capacity of liberating free rosin from size, and the pulps like alpha and rag which are usually hard to size possess this capacity to a far less degree than the more impure forms of cellulose fibers. Whether this alkali binding involves the processes of exchange adsorption as often referred to [Percival *(22)*] has not apparently been completely demonstrated. Possibly it is more to be associated with acidic materials resulting from cellulose splitting and oxidation, rather than with exchange involving small amounts of ash constituents. The effects are much too large to ascribe readily to ash content.

It is of interest and considerable importance to note that the equilibrium of ionic distribution between the fiber and its environment does not establish itself spontaneously, and to the extent of applicability of the Donnan theory of swelling to cellulose, hydration maxima, as a consequence of ionic distribution, are likewise delayed over very long intervals of time. When, for example, pulp is selectively and hydrolytically removing alkali from rosin soap, the action is in many cases no more than half completed within a period of one hour. According to such data, rosin size put into a neutral beater should behave much more effectively if allowed to remain in contact with the furnish for a long period before the alum is added. The addition of alum not only brings to completion all chemical reactions involving the size, but, because of the adsorption characteristics of the pulp fibers for aluminum ions and hydrous alumina, effects the desirable conditions of receptivity of the furnish for size. This may even involve a change of electrostatic charge from negative to positive. It may be appropriate at this point to emphasize the fact that the colloidal nature of cellulose as it pertains to the actual problems of paper making reaches its full significance only when considered in conjunction with the colloidal and chemical characteristics of the other ingredients of the furnish.

### Optical Properties

The general structure of cellulose fibers has been studied by Frey *(6)* and earlier by Herzog *(10)* who, on the basis of double refraction effects, was able to correlate the optical nature with spiral winding. That cellulose fibers, being of a pseudo-crystalline character, possess the property of double refraction renders the possibility of producing a completely transparent sheet more difficult, since it intensifies the difficulty of multiple scattering of light as it passes through layers of fibers. The phenomenon is, however, not without its advantages. Between crossed Nicols, the fiber stands out in brilliant illumination with an extinction position parallel with its long dimension. Since, in a sheet of paper, most fibers lie in the plane of the sheet, examination of a microsection under a polarizing microscope affords an experimental procedure to studying the distribution of noncellulosic materials within and upon the surface of the sheet, since these substances are generally isotropic and are extinguished by crossing the Nicols.

That the fiber may deviate still further optically from the usual is exemplified in the phenomenon of dichroism when cellulose has adsorbed a film of dye, [Preston *(23)*]. This behavior involves not only an adsorption of dye but a surface orientation in the adsorbed film. Another case of surface orientation by cellulose is that reported by Strachan *(31)* who noted that iodine adsorbed by cellulose is oriented as minute rhombic crystals giving rise to a structure acting to completely plane polarize transmitted light, so that when two fibers of this type become crossed, the area of intersection becomes opaque. It was possible to demonstrate an orientation of calcium carbonate and barium sulphate crystals grown on the fibers in a similar manner. The cellulose fiber thus has a distribution of surface forces of a regularity that might lend validity to the theories of bonding involving fiber-fiber force fields of definite distribution.

It is worthy of at least passing interest that the spacial distribution of surface energy which must occur on a fiber surface must be involved in the strength development of paper during the drying period. Like the life history of a soap bubble involving the drainage of free liquid between the lamellae so that eventually the double film may consolidate through an oriented film of stabilizing agent held mutually at both air-liquid interfaces, the liquid layer between pulp fibers may be removed to allow an intimate contact and overlapping of surface valencies to bring into effect the strength features of the furnish. As with the soap bubbles, these cementing forces of orientation will be given more favorable opportunity to seek their maximum adjustment if the drying can be carried on slowly and with the least possible interference from such conditions as will interfere with the normal tendency to contract.

It is suggested by Preston *(23)* that surface orientation studied by the experimental methods of absorption spectra should lead to an evaluation of surface changes through the paper making process. The phenomena also offers the exciting but rational possibility of making a completely opaque sheet without the use of filler. Such visions of the apparently incredible are often seen by the research worker and are now and then, with equal incredibility, realized.

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# Testing Methods for Evaluation of Unbleached Chemical Pulp*

By David Johansson[1]

**Abstract**

*A survey is given of the methods for determination of the cooking degree and strength properties used in the chief pulp-producing and pulp-consuming countries in Europe. Particular regard is paid to methods used in Sweden and their relation to other common methods.*

This paper will give a short description of methods commonly used in Sweden and draw a parallel with methods used in other countries.

**Determination of the Cooking Degree of Pulp**

As raw material for producing sulphite pulp the Swedish pulp mills use exclusively spruce (*Picea excelsa*) and for producing of sulphate pulp, mostly pine (*Pinus silvestris*). The content of rosin is 2 or 3 times higher in pine than in spruce but with the exception of this the chemical composition of the wood is nearly the same in these two species.

By the pulp cooking processes about 40 to 60 per cent of the wood material is dissolved in the cooking agents. The material dissolved is mostly hemicellulose and lignin. The remaining pulp fibers substantially consist of cellulose. Depending on the cooking process the pulp will also contain certain amounts of lignin and hemicellulose and depending upon these amounts the character of the pulp will vary. A high lignin content makes the pulp stronger and more difficultly bleachable. To control the cooking degree the lignin content must be determined.

**Lignin Determination**

Direct lignin determinations are made by treating the pulp with strong (72 per cent) sulphuric acid according to König *(1)* or with 40 per cent hydrochloric acid according to Willstätter and Zechmeister *(2)*. Several variants of these methods have been recommended. In this way the cellulose and hemicellulose will be dissolved and the insoluble residue is considered to be lignin. Yet the various methods will give different results on the same pulp. When using the hydrochloric method no accurate relation between the hydrochloric acid lignin content and the bleach consumption of different pulps is obtained. It is obvious that these lignin products cannot be identical wit hthe native lignin Hilpert *(3)* has recently proved that sugars such as fructose, saccharose and pentoses and higher carbohydrates built up of these sugars give a "sugar-lignin" in high yields by treatment according to these methods of lignin determination. The value of these methods therefore seems to be doubtful.

For the practical evaluation of the pulps, however, it is not necessary to know their real lignin content. It is sufficient to determine their consumption of oxidizing agents such as chlorine, bleaching powder or permanganate. This consumption will be dependent on the lignin content. In this way it will be possible to grade the pulps very distinctly by a simple test that can be carried out in a very short time and that will at the same time give the bleach consumption of the pulp, provided a relation has already been established between practical bleaching conditions and the test method.

The methods principally used, when grouped after the oxidizing medium, are the following:

*Gaseous chlorine:* Roe *(4)*.

*Line of chlorine:* Bergman *(5)*, Enso *(6)*, Sieber *(7)*.

*Permanganate:* Björkman *(8)*, Johnsen *(9)*, Roschier *(10)*, Swedish Committee Standard Method *(11)*, Oestrand Method *(12)*.

*Bromine:* Tingle *(13)*.

In Sweden the Roe method is generally used. The *Roe chlorine number* indicates the number of grams gaseous chlorine that will be absorbed in 15 minutes at 20 deg. C by 100 grams dry calculated pulp with 55 per cent moisture. The absorption of chlorine is very rapid. For this determination a modified type of Roe's original apparatus, constructed by D. Johansson (Fig. 1) is used.

The determination with aid of this apparatus is carried out as follows.

The specimen shall consist of about 2 grams oven-dry disintigrated pulp. With very strong pulps it is better to take only 1.5 or 1.0 grams of pulp. When placing the pulp in the reaction bottle care must be taken to have sufficient room for the glass-pipe which goes down to the bottom. The bottle is now placed under the side tube of the adapter of a bottle containing boiling water. This steaming is continued until the bottle has increased in weight 2.5 grams. In Fig. 2 is shown a practical way for steaming

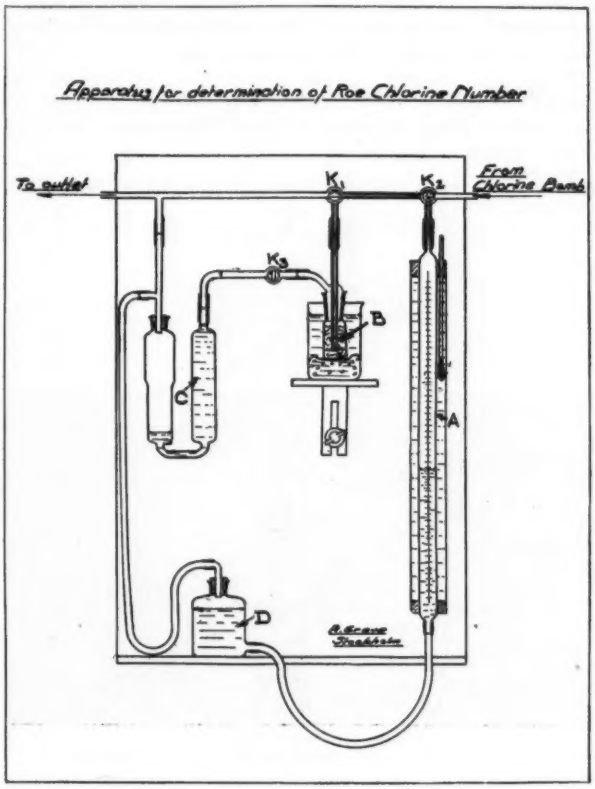


FIG. 1.

* Presented at the fall meeting of the Technical Association of the Pulp and Paper Industry, Atlantic City, N. J., September 18-21, 1935.

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the pulp. The determination can also be made on a thin sheet of the pulp which is moistened and placed in the bottle in a way that will give a large reaction surface.

Fig. 1 shows the layout of the apparatus. The liquid in the gas burette A is calcium chloride solution (30 grams $CaCl_2$ in 100 grams of water which is saturated with chlorine gas once a day). The liquid in the vessel C is also a solution of calcium chloride. This is filled to the mark on the left arm, and saturated with chlorine gas, which is led in by aid of $K_3$. (It is not necessary to do this if the apparatus is used every day). Thereafter an empty reaction bottle is put in place and the liquid in C is sucked to the top of the right arm. The cock $K_3$ is closed. The reaction bottle is taken away. $K_2$ is turned horizontal and chlorine gas is taken into the burette, which is rinsed twice with chlorine. About 100 cc. of chlorine are then taken in and the volume is read off after 2 or 3 minutes.

The reaction bottle with steamed pulp is cooled to 20 deg C, the ground point is well greased and the bottle attached to the apparatus. The water jacket containing water at 20 deg. C is put in place. Using the rubber sponge at the bottom of this water jacket the reaction bottle is pressed into place very carefully. The cock $K_2$ is urned around so that B only for a moment is in connection with the outside air. After that $K_2$ and $K_1$ are turned so that A and B are connected with each other. $K_3$ is opened and the leveling bottle is raised very slowly. The liquid in the right arm then sinks down. The adjustment is done with D, so that the whole system will be at atmospheric pressure. During the time the gas is being absorbed, D must be raised so the levels in A and D are the same. At the end of 15 minutes D is lowered until the liquid in C is again drawn up at the top in the capillary tube as in the beginning of the analysis. After that the cock $K_3$ is closed and a reading made of the volume of gas.

From the amount of gas absorbed is subtracted the amount of gas (4 cc.) obtained by running a blank determination using 2 grams of pure filter paper with 2.5 grams water.

The chlorine number is calculated according to the following formula:

$$\frac{0.0004168\ (V - 4)\ h}{f\ g}$$

V = volume chlorine gas absorbed in cm³.
h = barometric pressure in m/m Hg
f = 1 + 0.00367 t
t = deg. C.
g = grams oven-dry pulp.

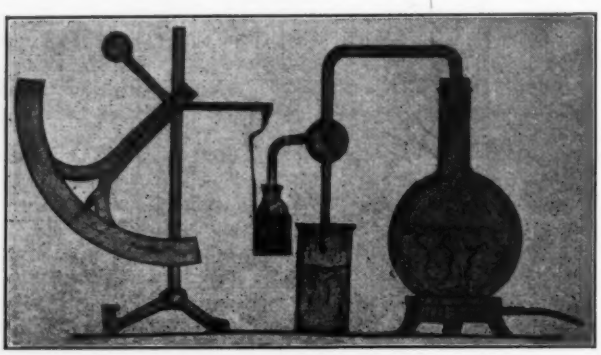

FIG. 2.

Apparatus used to add steam to a pulp suspension.

Gaseous chlorine has the great advantage over other oxidizing agents in that its action takes place by constant chlorine concentration during the whole reaction time, whereas the action of permanganate for example is dependent on the concentration of the solution at the beginning and the end of the reaction time.

Permanganate methods, however, may be preferred for routine analyses. The results can still be conveniently reported in Roe chlorine number. I have determined the relation between the permanganate consumption and the Roe chlorine number by two permanganate methods, the Oestrand method and the Swedish Standard Committee method.

As the Oestrand method is simpler and more rapid than the committee method I will only give the details of the former.

### Oestrand Permanganate Method

Air-dry, defibrated pulp, corresponding to 1.00 gram oven-dry pulp is put in a 750-cc. beaker with 180 cc. distilled water and 20 cc. sulphuric acid (1 volume conc. $H_2SO_4$ (spec. gr. 1.84) to 9 volumes water). The mixture is stirred by a mechanical stirrer of acid proof steel (500 r.p.m.) at a temperature of 20 deg. C. 50 cc. N/10 K Mn $O_4$ are added from a beaker and the stirring is thereafter continued for exactly 5 minutes, when the reaction is stopped by adding 50 cc. of N/10 $(NH_4)_2$ $Fe(SO_4)_2$ solution, containing 100 cc. of conc. sulphuric acid per liter. The stirring is continued until the solution is quite colorless. 150 cc. of clear solution is titrated with N/10 K Mn $O_4$ until the first red color shows.

Permanganate consumption per 2 grams oven-dry pulp is calculated and reported as Roe chlorine number by means of the graph (Fig. 3).

(The titer of the ferro-solution must be checked often against the permanganate solution).

By aid of the graphs the permanganate consumption can be transplanted to Roe chlorine number.

The Roe chlorine number varies between 1.5 and 13 for ordinary sulphite pulps and between 1.5 and 9 for ordinary sulphate pulps. In order to have all bleached and unbleached chemical pulps classified in whole numbers I have proposed *(14)* a new unit called the *Roe-unit* corresponding to one tenth of a Roe chlorine number.

CLASSIFICATION SCHEME OF SULPHITE AND SULPHATE* PULPS

| Sulphite | Roe chlorine number | Roe units | Sulphate | Roe chlorine number | Roe units |
|---|---|---|---|---|---|
| Bleached ..... | 0.1-0.5 | 1-5 | Bleached and half bleached ..... | 0.1-1.5 | 1-15 |
| Easy bleaching... | 1.5-3.0 | 15-30 | Easy bleaching... | 1.5-2.5 | 15-25 |
| Bleachable ..... | 3.0-4.5 | 30-45 | Light and strong. | 2.3-3.5 | 25-35 |
| Medium strong... | 4.5-7.0 | 45-70 | Strong ..... | 3.5-5.0 | 35-50 |
| Strong ..... | 7.0-13.0 | 70-130 | Kraft ..... | 5.0-9.0 | 50-90 |

In collaboration with the Central Laboratory at Helsingfors, the Research Institute of the Paper Industry in Oslo and the Waldhof laboratory in Mannheim the following relations between the Roe chlorine number and other numbers for the cooking degree of *sulphite pulps* have been found at Oestrand.

| Roe unit | Roe Chlorine No. | Bleach-consumption, per cent bleaching powder* | Bergman No. | Björkman No. | Tingle No. | Sieber Chlorine No. Oslo | Sieber No. Waldhof | Hardness scale Noll |
|---|---|---|---|---|---|---|---|---|
| 20 | 2 | 7.5 | 2.3 | 37 | 3.6 | 1.00 | 25 | 4.2 |
| 30 | 3 | 12.2 | 3.5 | 50 | 4.7 | 1.45 | 34 | 6.1 |
| 40 | 4 | 17.0 | 4.7 | 64 | 5.8 | 1.85 | 42 | 8.0 |
| 50 | 5 | 21.7 | 6.1 | 77 | 6.9 | 2.25 | 49 | 9.9 |
| 60 | 6 | 26.5 | 7.8 | 89 | 8.1 | 2.60 | 56 | 11.7 |
| 70 | 7 | 31.1 | 9.7 | 100 | 9.2 | 2.95 | 62 | 13.5 |
| 80 | 8 | 35.6 | 11.7 | 109 | 10.3 | 3.30 | 66 | 15.2 |
| 90 | 9 | 40.3 | 13.8 | 117 | 11.5 | 3.60 | 70 | 16.9 |
| 100 | 10 | 44.8 | 16.0 | 123 | 12.6 | 3.90 | 74 | 18.5 |

* 1-stage bleaching.

### Methods for Strength Testing

The strength of a pulp is defined as the strength of a test sheet produced according to a standardized method. It has been found important to test the strength of a pulp by different beating conditions. However, there are different opinions regarding the beating instrument as well as regarding the most convenient beating degree. Some strength properties such as the tensile strength and the bursting strength rise very rapidly in the first stage of the beating procedure but will be rather constant during higher beating degrees. This is one reason for choosing a beating degree of 45 degrees Schopper-Riegler as a standard point, which is done in the Northern countries. To have a complete picture of the behavior of the pulp by beating and of the development in strength it is necessary to test the strength of unbeaten (only defibrated) pulp at different stages of beating. "Beating curves" or "strength curves" are the results of these tests.

Different beating instruments will, however, give different strength values for the same beating degree, all other conditions for the production of the test sheets being the same.

There are many other variables which influence the character of the test sheets. The concentration of the pulp for sheet-making, the wire in the sheet machine, the weight of the sheet, the moisture before pressing, the kind of pressing, the pressing pressure, and the drying method.

During recent years standard methods for evaluating wood pulp on a strength basis have been developed in many countries. In the table some data are brought together of the most important European methods for strength testing.

| Method | English | Swedish | Finnish | Norwegian | German |
|---|---|---|---|---|---|
| **Defibration** | | | | | |
| Apparatus | Standard | Wennberg | Cameron | English type | No standard |
| Conc., grams per liter | 12 | 3 | 1 | 12 | " |
| R.p.m. | 3000 | 1390 | 1700 | 2800 | " |
| Time (minutes) | 25 | 15 | 15 by sulphite 55 by sulphate | 5 | " |
| **Beating** | | | | | |
| Apparatus | No beating | Lampén | Valley (Lampén) | Lampén | Jokromill |
| Beating degree | | 45° SR (Curve) (Wennberg) | Curve (50° SR) | 45° S.R. | Curve (Rapid-Köthen) |
| **Sheet making** | | | | | |
| Sheet machine | 16 cm | 21.6 cm | 10 x 30 | 12 x 25 | 20 cm |
| Mesh | 150 | 80 | 100 | 150 | 150 |
| Conc., grams per liter | 0.172 | 0.25 | 0.375 | 0.19 | 0.25-0.30 |
| Substance, grams per square meter | 60 | 100 | 66.7 | 66.7 | 75 |
| **Pressing** | | | | | |
| First time kg/cm² | 3.5 kg—5 min. | 1 kg — ½ min. | 5.4 kg—5 min. | 2.5 kg—3 min. | Rapid-Köthen |
| Second time kg/cm² | 3.5 kg—2 min. | 15 kg — 1 min. | | 7 kg — 3 min. | (1 kg/cm²) |
| **Drying** | | | | | |
| Apparatus | Drying rings | Cylinder Ferrotype plates | Cylinder Between blotters | Cylinder Ferrotype plates | Rapid-Köthen |
| Temperature | 20 deg. C. | 60 deg. C. | 65 deg. C. | 50 deg. C. | 100 deg.C. |

The Swedish method is worked out by a committee (members Folin, Hall, Lindström, Palm and Sundblad) and was published 1931 *(15)*. The Lampén mill is used as a beating instrument which gives more reproducible values than the Valley beater and other instruments. The sheet machine is of the round type, the wire being stretched very hard and having no supports. The sheet machine which is constructed by S. Sandberg is very easy to handle and permits very rapid work.

By the English standard method *(16)* the pulp is disintegrated corresponding only to a very weak beating. The strength values thus obtained (initial strength) are very much dependent upon the age and moisture content of the pulp. A wet pulp gives in this way a much higher tensile strength and bursting strength and lower tearing strength than the same pulp if dried. By beating to the same beating degree this difference will be rather small. A fresh pulp will also give higher tensile and bursting strength values than an old pulp. The reason for this is that a constant disintegrating time will give a dry or an old pulp a lower beating degree (higher freeness) than a wet or a fresh pulp.

It seems to be more convenient to characterize the pulps by beating to certain beating degrees and by determining the variation of the strength properties with the beating degree than to simply disintegrate the pulp for a certain time.

The German procedure *(17)* recently adopted as a tentative standard method involves the evaluation of a beating curve by beating in a new instrument called a Jokromill after the designers Jonas and Kross. The sheet is made up on a round sheet machine and is not removed from the wire but dried in a special drier, ("Rapid-Köthen," constructed by B. v. Possanner), held on the wire by means of a rubber bag filled with water at 100 deg. C. and a vacuum established beneath the wire.

A comparison has been made at Oestrand between the Swedish and the German method of sheet making and it was found that the Swedish method gives higher values when using identical pulp samples.

The differences in the methods of sheet making will make it impossible to get the same strength values even if the pretreatment of the pulp is the same. There are many factors affecting the results. One of them is the method of pressing the sheets before drying. On unbeaten sheets in particular the influence of the pressure is very

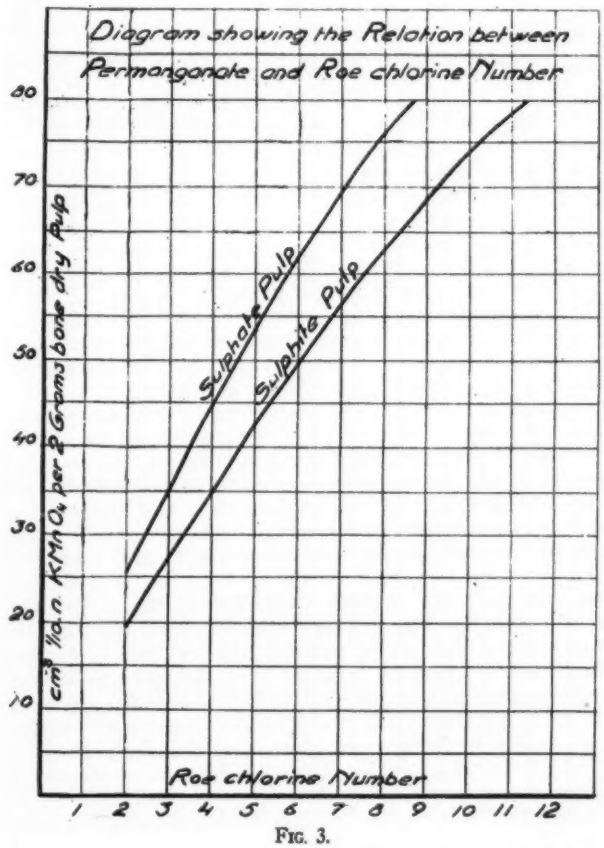


FIG. 3.

high. A high pressure will give a higher apparent specific gravity (lower bulk) of the sheet and at the same time higher strength values.

The chances for introducing an international standard method at present seems to be poor as all the methods involve rather complicated and expensive apparatus. It would be commendable to agree to those details which can be introduced without requiring alterations in the equipment e.g. the substance of the sheet, the fiber concentration by sheet making and the methods for pressing and drying the sheets.

The testing of the sheets, throughout Europe is carried out at 65 per cent relative humidity and at about 20 deg C. In Sweden the motor-driven Schopper tensile tester, the motor-driven Mullen tester, the Thwing-Elmendorf tearing tester and the Schopper folding endurance tester are used. In some laboratories other instruments are also in use e.g. the Schopper-Dahlén bursting strength tester and the M.I.T. folding endurance tester. A new Swedish folding tester has just come into the market. It is constructed by S. Köhler and seems to work very satisfactorily.

The physical tests are intended to give information about the paper-making properties of the pulp. The real value of the tests can therefore only be found out by simultaneous investigations on the behavior of the pulp in the actual paper mill treatment.

By laboratory beating tests it is possible to find out other properties than strength. The suitability of the pulp for special papers, e.g., grease proof, etc., is often tested out in a similar way.

### Relation Between Chemical and Physical Properties of Pulp

The physical properties of the pulp are dependent partly on the size of the fibers and partly on their chemical composition. In addition to that, the origin of the fibers plays an important rôle. Therefore it is not possible to predict the paper-making properties on the basis of chemical tests alone. The chemical composition is the same whether the fibers are cut into small pieces or left intact. The chemical composition does not entirely control the strength and other properties of a paper made of such fibers. No definite differences are found in the chemical composition of the springwood fibers and the summerwood fibers but a different percentage of these kinds of fibers will give different strength properties and different behavior to the pulps on beating. There is also no definite difference stated in the chemical composition of fibers from pines from the Southern states of the United States and from Swedish pine but the former will give a much weaker pulp than the latter.

It will however be possible to draw some conclusions about the physical properties of the pulps from the chemical tests if the pulp is produced according to the common methods. In most sulphite mills the different qualities are obtained by changing the cooking time and temperature and not very often by changing the acid composition in the same mill. If the same raw material is used there will then be a relation between the cooking degree (chlorine number) and the strength properties of the pulps. The tensile and bursting strength will rise with the chlorine number and the tearing strength and the time of beating to a standard beating degree will at the same time drop slowly. The changes are greatest for low chlorine numbers.

In the sulphate mills the changes in quality are caused by changes in the amount of cooking chemicals added as well as by changes in cooking time and temperature. When using the same raw material pulps of different cooking degrees will result. The tensile and bursting strengths show a marked rise with the chlorine number in the range of bleachable and light and strong pulps. For changes in chlorine numbers in the kraft pulp range there are rather small changes in these strength properties. The tearing strength shows first an increase for kraft pulps and then a slow decrease for increasing chlorine numbers. The beating time for a standard beating degree will rise with the chlorine number. The darker the color of the sulphate pulp, the higher the chlorine number, if other conditions in the mill are unchanged.

Of course there are sulphite pulps from different mills with the same chlorine numbers but with different strength properties. That depends on differences in the raw material, in the cooking acid composition, in the cooking conditions and in the treatment of the pulp after cooking It may be possible, for instance to make sulphite pulps with a higher content of hemicellulose for a given chlorine number. Such a pulp will have a high tensile strength and very rapidly reach a high beating degree.

The same thing may be found for sulphate pulps and will depend upon differences in the raw material and general mill conditions.

In general, however, the chlorine number will be a good standard of value for unbleached chemical pulps.

### Summary

In recent years new physical and chemical methods for evaluating the quality of the unbleached pulp as a raw material for paper making have been developed. The chief methods are those for the determination of the cooking degree and the strength and beating properties of the pulps.

The lignin content is a measure of the cooking degree. Direct lignin determinations on pulps give different values according to the method used. More convenient are the determinations of the cooking degree based upon the consumption of an oxidizing agent such as gaseous chlorine, permanganate, or bleaching powder. In Sweden the Roe chlorine number is used as the standard method for estimating the cooking degree. A detailed description of the test is given. The Roe chlorine number may also be determined by a permanganate test, the Oestrand method, using a conversion curve. To get a classification of all sorts of half bleached and unbleached sulphite and sulphate pulps using whole numbers the proposal is made to calculate in Roe units, a Roe unit being one-tenth of a Roe chlorine number. A table for converting several constants for the cooking degree of sulphite pulp into Roe units is given.

A survey of the chief methods used in Europe for determination of the strength properties of the pulps is given. Some of the factors affecting the results are mentioned and the possibilities of reaching an international standard method discussed to some extent.

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(16) Interim report of the Pulp Evaluation Committee, Papermakers Assn. Gt. Britain and Ireland (1929).
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Ed. Note: Paper Trade J. 92, No. 22:50-52 (June 3, 1926), relates to the subject of this paper.

# IMPORTS OF PAPER AND PAPER STOCK

## NEW YORK, BOSTON, PHILADELPHIA AND OTHER PORTS

### NEW YORK IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

CIGARETTE PAPER

Champagne Paper Corp., Ile de France, Havre, 331 cs.; Standard Products Corp., Ile de France, Havre, 56 cs.; R. J. Reynolds Tobacco Co., Washington, Havre, 50 cs.; De Manduit Paper Corp., Washington, Havre, 175 cs.

WALL PAPER

W. H. S. Lloyd Co., Britannic, London, 5 bls.; S. K. Lonegren, Bergensfjord, Oslo, 4 cs.; R. F. Downing & Co., Ryoyo Maru, Kobe, 11 bls.; ———, Washington, Havre, 19 cs.

WALL BOARD

Treetex Corp., Drottningholm, Gothenburg, 893 bdls, 1 cs.; ———, Svaneholm, Stockholm, 176 bdls.

NEWS PRINT

N. Y. Evening Journal, Markland, Liverpool, N. S., 183 rolls; N. Y. Tribune, Markland, Liverpool, N. S., 1,344 rolls; World Telegram, Markland, Liverpool, N. S., 611 rolls; Bridgeport Herald, Markland, Liverpool, N. S., 48 rolls; Brooklyn Daily Eagle, Markland, Liverpool, N. S. 255 rolls; Clinton Paper Corp., Markland, Liverpool, N. S., 363 rolls; ———, Bergensfjord, Oslo, 138 bls., 273 rolls; Jay Madden Corp., Pr. Harding, Hamburg, 131 rolls; International Paper Co., Cornerbrook, Dalhousie, 8,501 rolls; Bank of Montreal, Humberarm, Cornerbrook, 3,072 rolls; Jay Madden Corp., Washington, Hamburg, 203 rolls; Jay Madden Corp., Svaneholm, Kotka, 298 rolls; Gilman Paper Co., Svaneholm, Hallstavik, 508 rolls.

PRINTING PAPER

Steiner Paper Corp., Stuttgart, Bremen, 13 cs.; Steiner Paper Corp., Maasdam, Rotterdam, 40 cs.; Jay Madden Corp., Washington, Hamburg, 48 bls., 68 rolls.

WRAPPING PAPER

Scharf Bros. Black Condor, Rotterdam, 4 cs.; Scharf Bros., Maasdam, Rotterdam, 3 cs.; Blauvelt Wiley Paper Manfg. Co., Drottningholm, Gothenburg, 20 rolls.

DRAWING PAPER

Japan Paper Co., American Banker, London, 1 cs.; H. Reeve Angel & Co., Inc., Britannic, London, 1 cs.

BRISTOL BOARDS

Devoe & Raynolds Co., American Banker, London, 1 cs.

FILTER PAPER

H. Reeve Angel & Co., Inc., Britannic, London, 11 cs.; H. Reeve Angel & Co., Inc., Washington, Southampton, 15 cs.; ———, Washington, Southampton, 10 bls., 18 cs.

SURFACE COATED PAPER

Hensel Bruckman & Lorbacher, Stuttgart, Bremen, 7 cs.; Chas. Happel, Washington, Hamburg, 2 cs.

BARYTA COATED PAPER

Globe Shipping Co., Stuttgart, Bremen, 5 crates.

METAL COATED PAPER

K. Pauli Co., Stuttgart, Bremen, 68 cs.

PHOTO PAPER

Medo Photo-Supply Co., Britannic, London, 1 cs.

TRANSFER PICTURES

Rohner Gehrig & Co., Bremen, Bremen, 15 cs.

DECALCOMANIAS

Sellers Transportation Co., Bremen, Bremen, 9 cs.; L. A. Consmiller, Bremen, Bremen, 4 cs.

IVORY BOARDS

R. Wilson Paper Corp., Maasdam, Rotterdam, 13 cs.

STENCIL PAPER

———, E. Francqui, Antwerp, 3 cs.

CARD BOARD

International F'd'g Co., E. Francqui, Antwerp, 8 cs.

MISCELLANEOUS PAPER

———, Black Condor, Rotterdam, 26 rolls; Keuffel & Esser Co., Pr. Harding, Hamburg, 2 cs., 49 rolls; Applebee & Newman, Azumasan Maru, Kobe, 4 cs.; A. Giese & Son, Ile de France, Havre, 114 bls.; E. Fougera & Co., Ile de France, Havre, 19 cs.; Keller Dorian Paper Co., Excambion, Marseilles, 2 cs.; Japan Paper Co., Kirishima Maru, Kobe, 22 cs.; Moller Products Corp., Kirishima Maru, Yokohama, 13 cs.; The Borregaard Co., Inc., Drottningholm, Gothenburg, 481 rolls, 110 bls.; Blauvelt Wiley Paper Manfg. Co., Drottningholm, Gothenburg, 240 rolls; E. H. Sargent & Co., Drottningholm, Gothenburg, 2 cs.

RAGS, BAGGINGS, etc.

American Express Co., Black Condor, Rotterdam, 64 bls. rags; G. W. Millar Co., Winona County, Dublin, 51 bls. paper stock; G. W. Millar Co., Winona County, Glasgow, 26 bls. bagging; Bank of N. Y. Trust Co., Olympia, Barcelona, 104 bls. jute waste; Bank of N. Y. Trust Co., Olympia, Barcelona, 166 bls, rags; ———, Carinthia, Liverpool, 14 bls. old strings; Mitsui & Co., Ltd., Ryoyo Maru, Kobe, 20 bls. rags; ———, E. Fransqui, Antwerp, 191 bls. bagging; ———, E. Francqui, Antwerp, 11 bls. paper stock; Van Oppen & Co., E. Francqui, Antwerp, 318 bls. bagging; Chase National Bank, E. Francqui, Antwerp, 48 bls. jute waste; ———, Excambion, Alexandria, 71 bls. rags; E. J. Keller Co. Inc., Excambion, ———, 52 bls. bagging; E. J. Keller Co. Inc., Excambion, ———, 470 bls. paper stock; E. J. Keller Co. Inc., Kirishima Maru,

———, 170 bls. bagging; ———, M. Arnus, Barcelona, 44 bls. rags; ———, Lehigh, Manchester, 34 bls. cotton waste; ———, Lehigh, Liverpool, 27 bls. bagging; ———, Quaker City, Leith, 196 bls. bagging; E. J. Keller Co., Inc. Quaker City, ———, 208 bls. rags; ———, Montreal City, Bristol, 240 bls. rags; E. J. Keller Co., Inc., Maasdam, ———, 114 bls. bagging; E. J. Keller Co. Inc., Maasdam, ———, 406 bls. paper stock.

OLD ROPE

———, California, Glasgow, 75 coils; ———, Quaker City, Leith, 78 coils; S. Birkenstein & Son, Montreal City, Bristol, 46 coils.

CHINA CLAY

Whitaker Clark & Daniels, Carinthia, Liverpool, 390 bags.

WOOD PULP BOARDS

H. Fuchs & Son, Drottningholm, Gothenburg, 101 crates; ———, Svaneholm, Wiipuri, 350 rolls.

BAGASSE FOR PAPER PULP

W. R. Grace & Co., Santa Barbara, Salaverry, 5,947 bls., 252,206 kilos.

WOOD PULP

———, Bergensfjord, Sarpsborg, 150 bls. sulphite; Perkins Goodwin & Co., Bergensfjord, Drammen, 1,750 bls. sulphite; The Borregaard Co. Inc., Bergensfjord, Sarpsborg, 840 bls. sulphate; ———, Pr. Harding, Hamburg, 110 bls. wood pulp, 11 tons; M. Sone, Pr. Harding, Hamburg, 848 bls. wood pulp, 130 tons; ———, Black Hawk, Rotterdam, 808 bls. wood pulp, 162 tons; Price & Pierce, Ltd., Drottningholm, Gothenburg, 500 bls. dry pulp; D. M. Hicks, Inc., Drottningholm, Gothenburg, 210 bls. sulphite; Perkins Goodwin & Co., Drottningholm, Gothenburg, 140 bls. sulphate; E. M. Sergeant Pulp & Chemical Co., Drottningholm, Gothenburg, 175 bls. sulphite; ———, Washington, Hamburg, 120 bls. wood pulp, 12 tons; M. Sone, Washington, Hamburg, 648 bls. wood pulp, 100 tons; Castle & Overton, Inc., Svaneholm, Wiipuri, 5,382 bls. wood pulp; Lagerloef Trading Co., Svaneholm, Wiipuri, 5,200 bls. sulphite; Lagerloef Trading Co., Svaneholm, Kotka, 175 bls. sulphite; Lagerloef Trading Co., Svaneholm, Kotka, 770 bls. sulphate; Gottesman & Co., Inc., Sagoporack, Czecho-Slovakia, 324 bls. wood pulp.

## ALBANY IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

International Paper Co., Blankaholm, Newcastle, N. B., 2,300 cords pulpwood; International Paper Co., Hauk, Point-au-Pic, N. S., 900 cords pulpwood.

## PORTLAND IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

Gottesman & Co. Inc., Tigre, Sweden, 6,300 bls. wood pulp.

## BOSTON IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

G. M. Graves Co., Black Condor, Antwerp, 42 bls. paper stock; G. M. Graves Co., Black Condor, Antwerp, 21 bls. flax waste; ———, Black Condor, 108 bls. rags; Meredith Linen Mills, Black Condor, Antwerp, 89 bls. flax waste; ———, Winona County, Belfast, 84 bls. flax waste; Chase National Bank, Winona County, Glasgow, 40 bls. paper stock; G. F. Malcolm, Inc., Carinthia, Liverpool, 39 cs. tissue paper; ———, Excambion, Alexandria, 10 bls. rags; Atkinson Haserick & Co., Excambion, Genoa, 17 cs. paper; J. J. Ryan & Son, Inc., Kirishima Maru, Kobe, 200 bls. cotton waste; Gottesman & Co. Inc., Quaker City, Czecho-Slovakia, 657 bls. wood pulp.

## PHILADELPHIA IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

Castle & Overton, Inc., Black Condor, Antwerp, 100 bls. rags; ———, Black Condor, Antwerp, 31 bls. rags; American Sanitary Rag Co., Black Condor, Antwerp, 21 bls. rags; ———, Black Condor, Rotterdam, 50 rolls paper; Castle & Overton, Inc., Winona County, Glasgow, 97 bls. new cuttings; Mitsui & Co., Ltd., Ryoyo Maru, Kobe, 40 bls. rags; Union Waste Co., Kirishima Maru, Kobe, 75 bls. rags; Iwai & Co., Kirishima Maru, Kobe, 20 cs. paper; New England Waste Co., Kirishima Maru, Kobe, 100 bls. cotton waste; D. Galloway, Inc., Kirishima Maru, Kobe, 100 bls. cotton waste; E. J. Keller Co. Inc., Kirishima Maru, ———, 200 bls. rags; Moore & Munger, ———, Fowey, 363 tons, 14 cwt. china clay; English China Clays Corp., ———, Fowey, 762 tons, 11 cwt. china clay; J. A. Steer & Co., Montreal City, Bristol, 120 coils old rope; ———, Quaker City, London, 130 coils old rope; ———, Quaker City, Hull, 72 coils old rope; Perkins Goodwin & Co., Quaker City, Hamburg, 510 bls. tissue pulp, 90 tons; Perkins Goodwin & Co., Quaker City, Hamburg, 112 bls. sulphite, 22 tons; ———, Quaker City, Hamburg, 111 bls. rags.

## BALTIMORE IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

W. H. Masson, Winona County, Belfast, 99 coils old rope; S. George, Black Hawk, Rotterdam, 83 coils old rope.

## NEWPORT NEWS IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

———, Black Hawk, Rotterdam, 130 bls. wood pulp, 28 tons.

## NEW ORLEANS IMPORTS

WEEK ENDING SEPTEMBER 21, 1935

Gottesman & Co. Inc., Stureholm, Sweden, 2,000 bls. wood pulp.

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## Compensated Belt Construction

The Manhattan Rubber Manufacturing Division, Passaic, N. J., has just issued a new bulletin No. 6808-B describing and explaining the details of the construction of Condor Compensated Belt. Numerous interesting installation views show the wide acceptance of this belt, while charts and diagrams illustrate the valuable technical data which are of interest to all users of flat belting and make clear the reasons for the long service life and high operating efficiency of this Manhattan product.

Condor Compensated Belt embodies two new principles, one is the placing of the plies in such a manner that when flexed around the pulley, which is where the most strain occurs, each ply receives an equal amount of stress, eliminating ply ruptures and early fastener failures, and the other principle is the low tension pulley surface permitting the belt to run at very low tension. It is well known that high tension has been the chief course of premature belt failures.

## New York Market Review

Office of the PAPER TRADE JOURNAL,
Wednesday, September 25, 1935.

Conditions in the local paper market are showing signs of improvement. Demand for the various standard grades is fairly persistent. Sales forces of the leading paper organizations anticipate a good volume of orders in the next few months and the outlook for the balance of the year is bright.

The newsprint paper market is practically unchanged. Newspaper advertising during August increased 1.8 per cent over the corresponding month last year. Manufacturing operations in the United States, Canada and Newfoundland are proceeding in sufficient volume to take care of current requirements.

Steadiness prevails in the fine paper market. Demand for the various grades is improving. Quotations are firm, with higher prices in the near future predicted. Tissues are moving in fairly heavy volume. The coarse paper market is more active and it is reported that quotations will be advanced shortly.

### Mechanical Pulp

The position of the ground wood pulp market is considered fairly satisfactory. Production in North America and abroad is still keyed to consumption and the statistical position of the industry is sound. Prices of mechanical pulp are generally holding to previously quoted levels.

### Chemical Pulp

Demand for domestic and imported chemical pulp is brisk. The bright particular feature of the market is the continued strength of kraft pulp. Prices have again advanced and domestic kraft pulp is now quoted at from $1.75 to $1.85, while No. 1 imported kraft pulp is selling at from $1.75 to $1.80.

### Old Rope and Bagging

The old rope market is marking time. Demand for both domestic and foreign old manila rope is restricted. Small mixed rope is moderately active. No radical price changes have been reported. The bagging market is exhibiting a strong undertone, with offerings limited and prices steady to firm.

### Rags

Paper mill demand for new cotton rags is better than of late. Shirt cuttings are in excellent request, both for domestic and foreign consumption. New unbleached rags are firmer and are now qnoted at from 6.75 to 7.00. No. 1 white shirt cuttings are also displaying strength. The imported rag market remains unchanged.

### Waste Paper

The paper stock market is more active than for some time past. Board mill demand for the lower grades of waste paper is more in evidence and prices of strictly folded news and No. 1 mixed paper are steadier. The higher grades of paper stock are sharing the general improvement. Book stock is firmer.

### Twine

Now that the year is drawing to a close, demand for the various grades of twine is expanding. Supplies are moving into consumption in good volume. An encouraging factor in the situation is the improvement in the wrapping paper industry, which invariably influences the trend of the twine market.

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## New Audubon Catalogue

The Audubon Wire Cloth Corporation, Richmond street and Castor avenue, Philadelphia, has recently issued a 56 page Catalogue No. 40-19 covering its complete line, which includes illustrations, descriptions, specifications and list prices of its various products together with tables and useful information for selecting and specifying wire cloth.

Section 1, Mesh Wire Cloth includes the various grades of Double Crimped Wire Cloth specified by the number of openings per lineal inch from 1 to 120 in steel, brass, bronze, copper, monel, nickel and stainless steel and other ductile metals; extra fine mesh plain and twill weaves up to 325 mesh; filter cloth in all metals, meshes and weaves including fabricated filter units welded, brazed, banded, bound, gasketed, etc., ready for installation; tinned mill screen; brass milk strainer cloth, etc.

Section 2, space wire cloth includes the coarser and heavier grades of vibraloy abrasive resisting steel and plain steel woven wire cloth up to 6 inches opening with 1½ inch rods specified by the size of the space of clear opening between the wires in arc-loc crimp, double crimp, rolled rectangular opening, woven slot and welded slot types; also fabricated screen units rolled, formed, knuckled, welded, flanged, banded, etc., ready for installation.

Section 3, Flexible Wire Cloth includes standard spiral and various new, "patented" and "patent applied for" weaves which permit wire cloth to be used for conveyor and processing belts; also for washing, sorting and grading.

Copies of this catalogue No. 40-19 may be obtained by writing the manufacturer direct. They also have a 16 page Catalog No. 40-19 featuring Flexible Wire Cloth which is a reprint of that section in their general Catalogue; also an 8 page condensed Catalogue No. 42-19 which describes their entire line but includes no specifications or list prices.

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## Resigns From St. Regis

BOSTON, Mass., September 23, 1935—After nearly twenty years' connection with the St. Regis Paper Company as Northeast Representative, Llewellyn A. (Lew) Marr has sent in his resignation to take effect at once. Mr. Marr will retain for the present his office at 176 Federal street, Boston, where he has been located for more than thirty years.

# Miscellaneous Markets

Office of the PAPER TRADE JOURNAL,
Wednesday, September 25, 1935.

BLANC FIXE.—Steadiness prevails in the blanc fixe market. Prices are holding to previously quoted levels. The pulp is quoted at from $42.50 to $45 per ton, in bulk; while the powder is selling at from 3½ to 3¾ cents per pound, in barrels, at works.

BLEACHING POWDER.—The bleaching powder market is exhibiting a strong undertone. Shipments against contract are moving in good volume. Prices are steady to firm. Bleaching powder is quoted at from $1.90 to $2.15 per 100 pounds, in drums, at works.

CASEIN.—The casein market is firm. Domestic standard ground is quoted at 11¼ and finely ground at 11¾; French standard ground at 12¼ and finely ground at 12¾; Argentine standard ground at 12½ and finely ground at 13 cents per pound, all in bags, car lot quantities.

CAUSTIC SODA.—Some improvement transpired in the caustic soda market. The contract movement is well up to average. Solid caustic soda is quoted at from $2.60 to $3.10; while the flake and ground are selling at from $3 to $3.05 per 100 pounds, in drums, at works.

CHINA CLAY.—The china clay market is displaying strength. Contract shipments are moving regularly. Imported china clay is still quoted at from $13.50 to $21 per ton, ship side; while domestic paper making clay is selling at from $6.50 to $12 per ton, at mine.

CHLORINE.—Paper mill demand for chlorine is brisk. The contract movement is fairly heavy. Prices are holding to schedule, without difficulty. Chlorine is quoted at from $2 to $2.40 per 100 pounds, in tanks, or multi-unit cars, in ton lots, or over, at works.

ROSIN.—The rosin market is firmer. Paper making gum rosin is now quoted at $4.25 and wood rosin at $4.20 per 280 pounds, gross weight, in barrels, at Savannah. Seventy per cent rosin size is selling at $2.52 per 100 pounds, in tank cars, at works.

SALT CAKE.—Business in the salt cake market is improving. Prices are well sustained. Salt cake is quoted at from $12 to $13; and chrome salt cake at from $11 to $12 per ton, at works. Imported salt cake is selling at from $12 to $13 per ton, ship side.

SODA ASH.—The soda ash market is fairly buoyant. Demand from the paper mills is better. Prices are steady to firm. Quotations on soda ash, in car lots, at works, per 100 pounds, are as follows: in bulk, $1.05; in bags, $1.20; and in barrels, $1.50.

STARCH.—Trading in the starch market is more active. The contract movement is satisfactory for the season. Prices remain unchanged. Special paper making starch is quoted at $3.59 per 100 pounds, in bags; and at $3.86 per 100 pounds, in barrels, at works.

SULPHATE OF ALUMINA.—The position of the sulphate of alumina market is practically unchanged. Prices are firm. Commercial grades are quoted at from $1.35 to $1.50; while iron free is selling at from $1.90 to $2.05 per 100 pounds, in barrels, at works.

SULPHUR.—The sulphur market continues steady. Sulphur is quoted at $18 per long ton on orders of 1,000 tons, or over, on yearly contracts; and at $20 per ton on any smaller quantity over that period. On spot and near by car loads, the quotation is $21 per ton.

TALC.—Conditions in the talc market are fairly satisfactory. Prices are holding to formerly quoted levels. Domestic talc is quoted at from $16 to $18 per ton, at eastern mines; while imported talc is selling at from $23 to $30 per ton, on dock.

# Market Quotations

## Paper

(F. o. b. Mill)

| | | | |
|---|---|---|---|
| Ledgers | 6.50 | @ | — |
| Bonds | 6.00 | @ | — |
| Index | 6.00 | @ | — |
| Writings— | | | |
| Extra Superfine | 6.50 | @ | — |
| Superfine | 6.25 | @ | — |
| Tub sized | 5.75 | @ | — |
| Engine sized | 5.50 | @ | — |
| Book, Cased— | | | |
| S. & S. C. | 5.35 | @ | 5.75 |
| S. & S. C. Litho | 5.60 | @ | 6.00 |
| M. F. | 5.10 | @ | 5.50 |
| Coated and Enamel | 5.90 | @ | 6.55 |
| Coated Litho | 5.90 | @ | 6.55 |
| Tissues—Per Ream— | | | |
| White No. 1 | .82½ | @ | .85 |
| White No. 2 | .67½ | @ | — |
| Anti-Tarnish M. G. only | 1.00 | @ | — |
| Colored | .85 | @ | — |
| Kraft | .70 | @ | — |
| Manila | .67½ | @ | .70 |
| Manila— | | | |
| No. 1 Jute | 9.00 | @ | 9.25 |
| No. 2 Jute | 7.75 | @ | 8.50 |
| No. 1 Wood | 4.00 | @ | 5.25 |
| No. 2 Wood | 3.50 | @ | 4.00 |
| Butchers | 4.00 | @ | 4.50 |
| Fibre Papers— | | | |
| No. 1 Fibre | 4.25 | @ | 5.50 |
| No. 2 Fibre | 4.00 | @ | 4.75 |
| Common Bogus | 1.50 | @ | 3.00 |
| Screenings | 2.50 | @ | 3.50 |
| Glassine— | | | |
| Bleached | .11 | @ | — |
| Unbleached | .09 | @ | — |

(The following Quotations are Delivered New York)

| | | | |
|---|---|---|---|
| News, per ton— | | | |
| Roll, contract | 40.00 | @ | — |
| Rolls, spot | 40.00 | @ | — |
| Sheets | 45.00 | @ | — |
| Kraft— | | | |
| No. 1 Northern | 4.12½ | @ | 4.75 |
| Standard | 4.00 | @ | — |
| Southern | 3.87½ | @ | — |
| Boards—per ton— | | | |
| News | 32.50 | @ | 35.00 |
| Chip | 32.50 | @ | 35.00 |
| Sgl. Mla. Ll. Chip | 45.00 | @ | 47.50 |
| Jute Lined Chip | 45.00 | @ | 47.50 |
| White Patent Coated | 55.00 | @ | 57.50 |
| Binders Boards | 67.00 | @ | 75.00 |

## Mechanical Pulp

(On Dock, Atlantic Ports)

| | | | |
|---|---|---|---|
| No. 1 Imported— | | | |
| Moist | 21.00 | @ | 22.00 |
| Dry | 21.00 | @ | 22.00 |

(F. o. b. Mill)

| | | | |
|---|---|---|---|
| No. 1 Domestic and Canadian | 18.00 | @ | 24.00 |

## Chemical Pulp

(On Dock, Atlantic, Gulf and West Coast Ports)

| | | | |
|---|---|---|---|
| Bleached Sulphite (Domestic and Foreign)— | | | |
| Division 1 | 2.60 | @ | —* |
| Division 2 | 2.55 | @ | —* |
| Division 3 | 2.50 | @ | —* |
| Prime Qualities— | | | |
| Class 1. All Prime Easy Bleaching | 2.05 | @ | —* |
| Other Than Easy Bleaching— | | | |
| Class 2. Higher than Standard | 2.00 | @ | —* |
| Class 3, Standard | 1.95 | @ | —* |
| Class 4, Lower than Standard | 1.90 | @ | —* |

(On Dock, Atlantic Ports)

| | | | |
|---|---|---|---|
| Kraft No. 1 | 1.75 | @ | 1.80 |
| Kraft No. 2 | 1.60 | @ | 1.70 |

(F. o. b. Pulp Mill)

| | | | |
|---|---|---|---|
| Kraft Domestic | 1.75 | @ | 1.80 |

(Delivered)

| | | | |
|---|---|---|---|
| Soda Bleached | 2.50 | @ | — |

* Add 60 Cents per short ton, dock charges, for Albany; $2.00 for Lake Ports East and $3.00 for Lake Ports West of Mackinac Straits.

## Domestic Rags

### New Rags

(Prices to Mill f. o. b. N. Y.)

| | | | |
|---|---|---|---|
| Shirt Cuttings— | | | |
| New White, No. 1 | 6.00 | @ | 6.25 |
| Silesias No. 1 | 4.50 | @ | 4.75 |
| New Unbleached | 6.75 | @ | 7.00 |
| New Soft Blacks | 3.00 | @ | 3.25 |
| Blue Overall | 4.25 | @ | 4.50 |
| Fancy | 2.50 | @ | 2.75 |
| Washables | 1.75 | @ | 2.00 |
| Mixed Khaki Cuttings | 3.00 | @ | 3.25 |
| O. D. Khaki Cuttings | 3.75 | @ | 4.00 |
| Men's Corduroy | 1.50 | @ | 1.75 |
| New Mixed Blacks | 2.50 | @ | 2.75 |

### Old Rags

| | | | |
|---|---|---|---|
| White, No. 1— | | | |
| Repacked | 3.00 | @ | 3.50 |
| Miscellaneous | 2.75 | @ | 3.25 |
| White, No. 2— | | | |
| Repacked | 1.75 | @ | 2.25 |
| Miscellaneous | 1.50 | @ | 1.75 |
| Thirds and Blues— | | | |
| Repacked | 1.50 | @ | 1.75 |
| Miscellaneous | 1.25 | @ | 1.50 |
| Black Stockings | 2.50 | @ | 3.00 |
| Roofing Rags— | | | |
| No. 1 | 1.55 | @ | 1.60 |
| No. 2 | 1.30 | @ | 1.35 |
| No. 3 | .95 | @ | 1.00 |
| No. 4 | .95 | @ | 1.00 |
| No. 5A | .90 | @ | 1.00 |

## Foreign Rags

### New Rags

| | | | |
|---|---|---|---|
| New Dark Cuttings | 1.75 | @ | 1.85 |
| New Mixed Cuttings | 1.80 | @ | 1.90 |
| New Light Silesias | 3.75 | @ | 4.00 |
| Light Flannelettes | 3.75 | @ | 4.00 |
| Unbleached Cuttings | 6.50 | @ | 6.75 |
| New White Cuttings | 6.50 | @ | 6.75 |
| New Light Oxfords | 3.25 | @ | 3.50 |
| New Light Prints | 2.75 | @ | 3.00 |

### Old Rags

| | | | |
|---|---|---|---|
| No. 1 White Linens | 7.50 | @ | 8.00 |
| No. 2 White Linens | 6.50 | @ | 7.00 |
| No. 3 White Linens | 4.50 | @ | 5.00 |
| No. 4 White Linens | 2.25 | @ | 2.50 |
| No. 1 White Cotton | 4.25 | @ | 4.75 |
| No. 2 White Cotton | 3.25 | @ | 3.75 |
| No. 3 White Cotton | 2.50 | @ | 2.75 |
| No. 4 White Cotton | 1.90 | @ | 2.15 |
| Extra Light Prints | 2.00 | @ | 2.25 |
| Ord. Light Prints | 1.75 | @ | 1.85 |
| Med. Light Prints | 1.55 | @ | 1.65 |
| Dutch Blue Cottons | 1.75 | @ | 1.85 |
| French Blue Linens | 2.30 | @ | 2.40 |
| German Blue Linens | 2.15 | @ | 2.25 |
| German Blue Cottons | 1.70 | @ | 1.80 |
| Checks and Blues | 1.30 | @ | 1.40 |
| Linsey Garments | 1.95 | @ | 2.05 |
| Dark Cottons | 1.50 | @ | 1.60 |
| Old Shopperies | 1.00 | @ | 1.05 |
| New Shopperies | .95 | @ | 1.05 |
| French Blues | 1.70 | @ | 1.80 |

## Old Rope and Bagging

(Prices to Mill f. o. b. N. Y.)

| | | | |
|---|---|---|---|
| Gunny No. 1— | | | |
| Foreign | 1.70 | @ | 1.80 |
| Domestic | 1.50 | @ | 1.60 |
| Wool Tares, light | 1.65 | @ | 1.70 |
| Wool Tares, heavy | 1.75 | @ | 1.80 |
| Bright Bagging | 1.65 | @ | 1.70 |
| Manila Rope— | | | |
| Foreign | 1.85 | @ | 2.00 |
| Domestic | 1.75 | @ | 2.00 |
| Small Mixed Rope | 1.10 | @ | 1.35 |
| New Burlap Cut | 2.00 | @ | 2.25 |
| Hessian Jute Threads— | | | |
| Foreign | 2.60 | @ | 2.75 |
| Domestic | 2.80 | @ | 3.00 |

## Old Waste Papers

(F. o. b. New York)

| | | | |
|---|---|---|---|
| Shavings— | | | |
| White Envelope Cuttings | 2.45 | @ | 2.55 |
| Ordinary Hard White No. 1 | 2.10 | @ | 2.15 |
| Hard White No. 2 | 1.90 | @ | 2.00 |
| Soft White No. 1 | 1.70 | @ | 1.80 |
| Flat Stock— | | | |
| Stitchless | .65 | @ | .75 |
| Over issue Mag | .65 | @ | .75 |
| Solid Flat Book | .45 | @ | .50 |
| Crumpled No. 1 | .35 | @ | .40 |
| Solid Book Ledger | 1.50 | @ | 1.65 |
| Ledger Stock | 1.00 | @ | 1.10 |
| New B. B. Chips | .30 | @ | .35 |
| Manilas— | | | |
| New Env. Cut | 1.70 | @ | 1.80 |
| New Cuttings | 1.35 | @ | 1.45 |
| Print | Nominal | | |
| Bogus Wrapper | .40 | @ | .50 |
| Container | Nominal | | |
| Old Kraft Machine— | | | |
| Compressed bales | 1.10 | @ | 1.20 |
| News— | | | |
| No. 1 White News | 1.30 | @ | 1.35 |
| Strictly Overissue | .60 | @ | .65 |
| Strictly Folded | .40 | @ | .42½ |
| No. 1 Mixed Paper | .30 | @ | .32½ |

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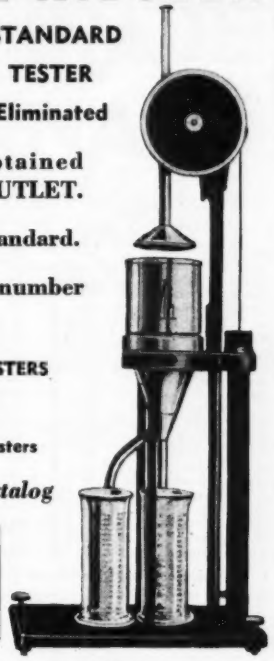

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*A Division of American Cyanamid Company*

### Twines
(F. o. b. Mill)

| | | | |
|---|---|---|---|
| Coarse Polished— | | | |
| India | .12¼ | @ | .14¼ |
| Belg. White Hemp | .13¼ | @ | .16¾ |
| India Compress | .12¾ | @ | .13¼ |
| Fine Polished— | | | |
| Fine India | .20 | @ | .22 |
| Special | .18 | @ | .20 |
| B. C. | .26½ | @ | .28½ |
| Unpolished— | | | |
| Box | .11 | @ | .11½ |
| Paper Makers | .08 | @ | .13 |
| Tube Rope | .09 | @ | .14½ |
| Wall Paper | .10 | @ | .13½ |
| Wrapping | .13½ | @ | .19½ |
| Special | .13½ | @ | .14 |
| Soft Fiber Rope | .11¼ | @ | .11¾ |

## CHICAGO

### Paper
(F. o. b. Mill)

| | | | |
|---|---|---|---|
| Rag Bond | .12 | @ | .50 |
| Water Marked Sulphite Bond | .06¾ | @ | .11 |
| Sulphite Bond | .05½ | @ | .11 |
| Superfine Writing | .18 | @ | .24 |
| No. 1 M. F. Book | .06½ | @ | .07¼ |
| No. 2 M. F. Book | .05¼ | @ | .06¼ |
| No. 1 S.&S.C. Book | .06¼ | @ | .07¼ |
| No. 2 S.&S.C. Book | .05¼ | @ | .06½ |
| Coated Book | .07 | @ | .12 |
| Coated Label | .07 | @ | .08½ |
| No. 1 Manila | .04¼ | @ | .05¾ |
| No. 1 Fibre | .04¾ | @ | .05¼ |
| No. 2 Manila | .04¼ | @ | .04¾ |
| Butcher's Manila | .03¼ | @ | .03¾ |
| No. 1 Kraft | 4.75 | @ | 5.00 |
| Southern Kraft | 3.88 | @ | 4.25 |
| No. 2 Kraft | 3.88 | @ | 4.25 |
| Wood Tag Boards | .04¼ | @ | .06¼ |
| Sulphite Screenings | .03 | @ | .03¼ |
| Manila Tissue | .05¾ | @ | .07 |
| White Tissue | .07 | @ | .09 |

(Delivered Central Territory)

| | | | |
|---|---|---|---|
| News, per ton— | | | |
| Rolls, contract | 41.00 | @ | — |
| Sheets, open | 46.00 | @ | 48.50 |
| Boards, per ton— | | | |
| Plain Chip | 46.50 | @ | — |
| Solid News | 50.00 | @ | — |
| Manila Lined Chip | 55.00 | @ | — |
| Patent Coated | 65.00 | @ | — |
| Container Lined— | | | |
| 85 Test, per 1000 sq. ft. | | | 1.70 |
| 100 Test, per 1000 sq. ft. | | | 1.85 |

### Old Papers
(F. o. b. Chicago)

| | | | |
|---|---|---|---|
| Shavings— | | | |
| No. 1 White Envelope Cuttings | 1.70 | @ | 2.00 |
| No. 1 Hard White | 1.40 | @ | 1.65 |
| No. 1 Soft White | 1.25 | @ | 1.50 |
| Ledger & Writings | .70 | @ | .80 |
| Solid Books | .60 | @ | .70 |
| Blanks | 1.00 | @ | 1.05 |
| Krafts | .80 | @ | .90 |
| New Kraft Cuts | 1.20 | @ | 1.30 |
| Manila Env. Cuts | 1.25 | @ | 1.30 |
| Ex. No. 1 Manila | .90 | @ | 1.00 |
| Print Manila | .40 | @ | .50 |
| Overissue News | .40 | @ | .45 |
| Old Newspapers— | | | |
| No. 1 | .30 | @ | .35 |
| No. 1 Mixed Paper | .25 | @ | .30 |
| Roofing Stocks— | | | |
| No. 1 | 30.00 | @ | — |
| No. 2 | 28.00 | @ | — |

## PHILADELPHIA

### Paper
(Delivered Philadelphia)

| | | | |
|---|---|---|---|
| Bonds | .05-9/10 | @ | .38 |
| Ledgers | .06-9/10 | @ | .40 |
| Writings— | | | |
| Fine No. 3 | .05 | @ | .06 |
| Superfine | .10 | @ | .12 |
| Extra Fine | .15 | @ | .26 |
| Fine | .15 | @ | .26 |
| Fine, No. 2 | .10 | @ | .25 |
| Book, M. F. | .05¼ | @ | .06¼ |
| Book, S. S. & C. | .05½ | @ | .07½ |
| Book, Coated | .06½ | @ | .09 |
| Coated Lithograph | .06¾ | @ | .08½ |
| Label | .07 | @ | .11 |
| No. 1 Jute Manila | 6.25 | @ | — |
| Manila Sul., No. 1 | 5.25 | @ | — |
| Manila No. 2 | 3.75 | @ | — |
| No. 1 Kraft | 5.00 | @ | — |
| Southern Kraft | 4.75 | @ | — |
| Common Bogus | .03 | @ | — |
| News Print Rolls | 40.00 | @ | — |
| Straw Board | 40.00 | @ | 45.00 |
| News Board | 40.00 | @ | — |
| Chip Board | 37.50 | @ | — |
| Wood Pulp Board | 70.00 | @ | 85.00 |
| Binder Boards— | | | |
| No. 1, per ton | 75.00 | @ | 80.00 |
| No. 2, per ton | 70.00 | @ | 75.00 |
| Carload lots | 65.00 | @ | 70.00 |
| Tarred Felts— | | | |
| Regular | 52.25 | @ | 54.25 |
| Slaters (per roll) | .84 | @ | .94 |
| Best Tarred, 1-ply (per roll) | 1.95 | @ | 2.10 |
| Best Tarred, 2-ply (per roll) | 1.40 | @ | 1.75 |
| Best Tarred, 3 ply | 2.00 | @ | 2.25 |

### Domestic Rags (New)
(Price to Mill, f. o. b. Phila.)

| | | | |
|---|---|---|---|
| Shirt Cuttings— | | | |
| New White, No. 1. | .03½ | @ | .04 |
| New White, No. 2. | .02½ | @ | .04 |
| Light Silesias | .02½ | @ | .03 |
| Silesias, No. 1 | .03 | @ | .03½ |
| Black Silesias, soft. | .02½ | @ | .03 |
| New Unbleached | .05 | @ | .05½ |
| Washable, No. 1 | .01½ | @ | .02 |
| Blue Overall | .03½ | @ | .04 |
| Cottons—According to grades— | | | |
| Washable, No. 2 | .02½ | @ | .03 |
| New Blue | .01½ | @ | .03 |
| Fancy | .01½ | @ | .03 |
| New Black Soft | .02 | @ | .04 |
| New Light Seconds | .01½ | @ | .02 |
| New Dark Seconds | 1.50 | @ | 1.75 |
| Khaki Cuttings— | | | |
| No. 1 O. D. | .03 | @ | .04 |
| No. 2 Mixed | .03 | @ | .04 |
| Corduroy | .02 | @ | .03 |
| New Canvas | .03½ | @ | .04½ |
| New Black Mixed | .02½ | @ | .03½ |

### Domestic Rags (Old)

| | | | |
|---|---|---|---|
| White No. 1— | | | |
| Repacked | 2.50 | @ | 3.50 |
| Miscellaneous | 1.75 | @ | 2.25 |
| M. G. | 3.00 | @ | 3.75 |
| Thirds and Blues— | | | |
| Miscellaneous | 1.00 | @ | 1.50 |
| Repacked | 1.50 | @ | 2.00 |
| Black Stockings (Export) | 2.00 | @ | 3.50 |
| Roofing Stock— | | | |
| Foreign No. 1 | .50 | @ | .75 |
| Repacked | .70 | @ | .85 |

### Bagging
(F. o. b. Phila.)

| | | | |
|---|---|---|---|
| Gunny, No. 1— | | | |
| Foreign | 1.25 | @ | 1.50 |
| Domestic | 1.50 | @ | 1.70 |
| Manila Rope | 2.00 | @ | 2.25 |
| Sisal Rope | 1.25 | @ | 1.50 |
| Mixed Rope | 1.00 | @ | 1.10 |
| Scrap Burlaps— | | | |
| No. 1 | 1.25 | @ | 1.50 |
| No. 2 | .80 | @ | 1.00 |
| Wool Tares, heavy | 2.75 | @ | — |
| Mixed Strings | 1.15 | @ | 1.25 |
| No. 1 New Light Burlap | 2.25 | @ | 2.50 |
| New Burlap Cuttings | 2.00 | @ | 2.25 |

### Old Papers
(F. o. b. Phila.)

| | | | |
|---|---|---|---|
| Shavings— | | | |
| No. 1 Hard White | 2.25 | @ | 2.30 |
| No. 2 Hard White | 1.90 | @ | 2.00 |
| No. 1 Soft White | 1.80 | @ | 1.85 |
| No. 2 Soft White | 1.25 | @ | 1.30 |
| No. 1 Mixed | — | @ | .75 |
| Solid Ledger Stock | 1.50 | @ | 1.60 |
| Writing Paper | 1.00 | @ | 1.10 |
| No. 1 Books, heavy | .55 | @ | .60 |
| No. 1 New Manila | 1.50 | @ | — |
| Print Manila | .50 | @ | .60 |
| Container Manila | — | @ | .50 |
| Old Kraft | 1.00 | @ | — |
| No. 1 Mixed Paper | — | @ | .30 |
| Straw Board Chip | .40 | @ | — |
| Binders Board Chip | .40 | @ | — |
| Corrugated Board | .55 | @ | — |
| Overissue News | .60 | @ | — |
| Old Newspapers | .40 | @ | — |

## BOSTON

### Paper
(F. o. b. Mill)

| | | | |
|---|---|---|---|
| Ledgers— | | | |
| Sulphite | .06 | @ | .12¼ |
| Rag Content | .12 | @ | .30 |
| All Rag | .36 | @ | .52½ |
| Bonds— | | | |
| Sulphite | .07¼ | @ | .11 |
| Rag Content | .12 | @ | .30 |
| All Rag | .36 | @ | .65 |
| Writings | .06½ | @ | .20 |
| Superfines | .11 | @ | .31 |
| Book, Super | .06 | @ | .09 |
| Book, M. F. | .05½ | @ | .08½ |
| Book, Coated | .08½ | @ | .18 |
| Coated Litho | .09 | @ | .12 |
| Label | .09½ | @ | .15 |
| Jute Manila No. 1 | .11 | @ | .13 |
| Manila, Sul. No. 1 | .04¼ | @ | .06¼ |
| Manila, Sul. No. 2 | .03¼ | @ | .04½ |
| No. 1 Kraft | .04¼ | @ | .05 |
| No. 2 Kraft | .04½ | @ | .04¾ |
| (F. o. b. Boston) | | | |
| Southern Kraft | .03¾ | @ | .04½ |
| (F. o. b. destination in carload lots, f. o. b. mill in less than carload lots) | | | |
| Common Bogus | .02 | @ | .02¾ |
| (Delivered New England points) | | | |
| News Print Rolls | 39.50 | @ | — |
| Straw Board, rolls | .009 | — | @35.00 |
| Straw Board in Sheets, basis 35s to 70s | — | | @40.00 |
| Filled News Board | 40.00 | | @45.00 |
| Chip Board | 37.50 | | @40.00 |
| Chip Board (Creasing) | 37.50 | | @40.00 |
| Single Manila Lined Chip | 47.50 | | @52.50 |
| Single White, Patent Coated News Board (Bender) | 55.00 | | @65.00 |
| Wood Pulp Board | 70.00 | | @75.00 |
| Binder Boards (Standard Grade) | 67.00 | | @75.00 |

### Old Papers
(F. o. b. Boston)

| | | | |
|---|---|---|---|
| Shavings— | | | |
| No. 1 Hard White | 2.00 | @ | 2.20 |
| No. 1 Soft White | 1.75 | @ | 1.90 |
| No. 2 Mixed | .75 | @ | .80 |
| Solid Ledger Books | 1.40 | @ | 1.50 |
| Overissue Ledger Stock | 1.15 | @ | 1.30 |
| Mixed Ledgers | .85 | @ | .90 |
| No. 1 Books, heavy | .55 | @ | .65 |
| No. 1 Books, light | .50 | @ | .60 |
| Crumpled Stitchless Book Stock | .50 | @ | .60 |
| Manila Env. Cuttings | 1.30 | @ | 1.40 |
| No. 1 Old Manila | .60 | @ | .65 |
| White Blank News | 1.25 | @ | 1.30 |
| No. 1 Kraft | 1.00 | @ | 1.05 |
| Mixed Papers | .27½ | @ | .30 |
| Print Manila | .50 | @ | .60 |
| Container Manilas | .27½ | @ | — |
| Old Newspapers | .27½ | @ | .30 |
| Overissue News | — | @ | .35 |
| Box Board Chips | — | @ | .25 |
| Corrugated Boxes | .35 | @ | .37½ |
| Screening Wrappers | .40 | @ | .45 |

### Bagging
(F. o. b. Boston)

| | | | |
|---|---|---|---|
| Manila Rope— | | | |
| Foreign | 1.80 | @ | 1.90 |
| Domestic | 1.50 | @ | 1.75 |
| Transmission Rope | .90 | @ | 1.00 |
| Jute Rope | 1.50 | @ | 1.60 |
| Jute Carpet Threads | .65 | @ | .70 |
| Gunny No. 1— | | | |
| Foreign | 1.85 | @ | — |
| Domestic | 1.50 | @ | — |
| Bleachery Burlap | 4.00 | @ | 4.50 |
| Scrap Burlap— | | | |
| Foreign | 1.75 | @ | 1.85 |
| Domestic | 1.60 | @ | — |
| Scrap Sisal | 1.30 | @ | 1.35 |
| Scrap Sisal for Shredding | 1.35 | @ | 1.50 |
| Wool Tares, heavy | 1.75 | @ | 1.85 |
| New Burlap Cuttings | 1.75 | @ | 1.90 |
| Australian Wool Pouches | 2.50 | @ | 2.75 |
| Heavy Baling Bagging | 1.75 | @ | 2.00 |
| Paper Mill Bagging | 1.25 | @ | — |
| Bagging No. 2 | .90 | @ | .95 |

### Domestic Rags (New)
(F. o. b. Boston)

| | | | |
|---|---|---|---|
| Shirt Cuttings— | | | |
| New Light Prints | .01¾ | @ | .02 |
| New White No. 1 | .06 | @ | .06¼ |
| New White No. 2 | .04 | @ | .04½ |
| Silesias No. 1 | .04¼ | @ | .04½ |
| New Black Silesias | .02½ | @ | .03 |
| Soft Unbleached | .06½ | @ | .06¾ |
| Blue Cheviot | — | @ | 4.65 |
| Fancy | .0195 | @ | .021 |
| Washable | .0165 | @ | .0170 |
| Cottons—According to grades— | | | |
| Blue Overalls | .04½ | @ | .04¾ |
| New Black, soft | .04 | @ | .04¾ |
| Khaki Cuttings | .03½ | @ | .03¾ |
| O. D. Khaki | .03 | @ | .03¼ |
| Corduroy | .01¾ | @ | .02 |
| New Canvas | — | @ | .05 |
| B.V.D. Cuttings | — | @ | .06¼ |
| Paper Mill Bagging | 1.10 | @ | 1.25 |

### Domestic Rags (Old)
(F. o. b. Boston)

| | | | |
|---|---|---|---|
| Canvas | .04½ | @ | — |
| White No. 1— | | | |
| Repacked | — | @ | 2.75 |
| Miscellaneous | 2.50 | @ | 2.75 |
| White No. 2— | | | |
| Repacked | 1.90 | @ | 2.00 |
| Miscellaneous | 2.00 | @ | 2.25 |
| Twos and Blues | 1.50 | @ | 2.00 |
| Thirds and Blues— | | | |
| Repacked | 1.37½ | @ | 1.75 |
| Miscellaneous | 1.25 | @ | 1.62½ |
| Black Stockings | 2.50 | @ | 3.00 |
| Roofing Stock— | | | |
| No. 1 | 1.50 | @ | 1.60 |
| No. 2 | 1.35 | @ | 1.40 |
| No. 3 | 1.05 | @ | 1.15 |

### Foreign Rags
(F. o. b. Boston)

| | | | |
|---|---|---|---|
| Dark Cottons | 1.60 | @ | 1.70 |
| New White Shirt Cuttings | 5.50 | @ | 6.00 |
| Dutch Blues | 2.25 | @ | 2.50 |
| New Checks & Blues | 2.50 | @ | 3.00 |
| Old Fustians | 1.90 | @ | — |
| Old Linsey Garments | 1.70 | @ | 2.00 |
| New Silesias | 4.75 | @ | — |

## TORONTO

### Paper
(F. o. b. Mill)

| | | | |
|---|---|---|---|
| Bond— | | | |
| No. 1 Sulphite | .11 | @ | — |
| No. 2 Sulphite | .08½ | @ | — |
| No. 1 Colored | .12 | @ | — |
| No. 2 Colored | .09 | @ | — |
| Ledgers (sulphite)— | | | |
| Ledgers, No. 1 | .34½ | @ | — |
| Ledgers, No. 2 | .25½ | @ | — |
| Writing | .09 | @ | .09½ |
| Book— | | | |
| No. 1 M. F. (Carloads) | 6.50 | @ | — |
| No. 2 M. F. (Carloads) | 6.00 | @ | — |
| No. 3 M. F. (Carloads) | 5.50 | @ | — |
| No. 1 S. C. (Carloads) | 7.00 | @ | — |
| No. 2 S. C. (Carloads) | 6.50 | @ | — |
| No. 3 S. C. (Carloads) | 5.20 | @ | — |
| No. 1 Coated and Litho | 12.00 | @ | — |
| No. 2 Coated and Litho | 10.50 | @ | — |
| No. 3 Coated and Litho | 9.50 | @ | — |
| Coated tinted | 13.00 | @ | — |
| Wrapping—delivered— | | | |
| Rag Brown | 4.75 | @ | — |
| White Wrap | 3.50 | @ | — |
| "B" Manila | 5.25 | @ | — |
| No. 1 Manila | 5.40 | @ | — |
| Fiber | 5.40 | @ | — |
| Kraft, M. F. | 5.90 | @ | — |
| Kraft, No. 2 | 5.40 | @ | — |

(F. o. b. Cars Toronto)

| | | | |
|---|---|---|---|
| News, per ton— | | | |
| Rolls (contract) | 39.50 | @ | — |
| Sheets | 44.50 | @ | — |

### Pulp

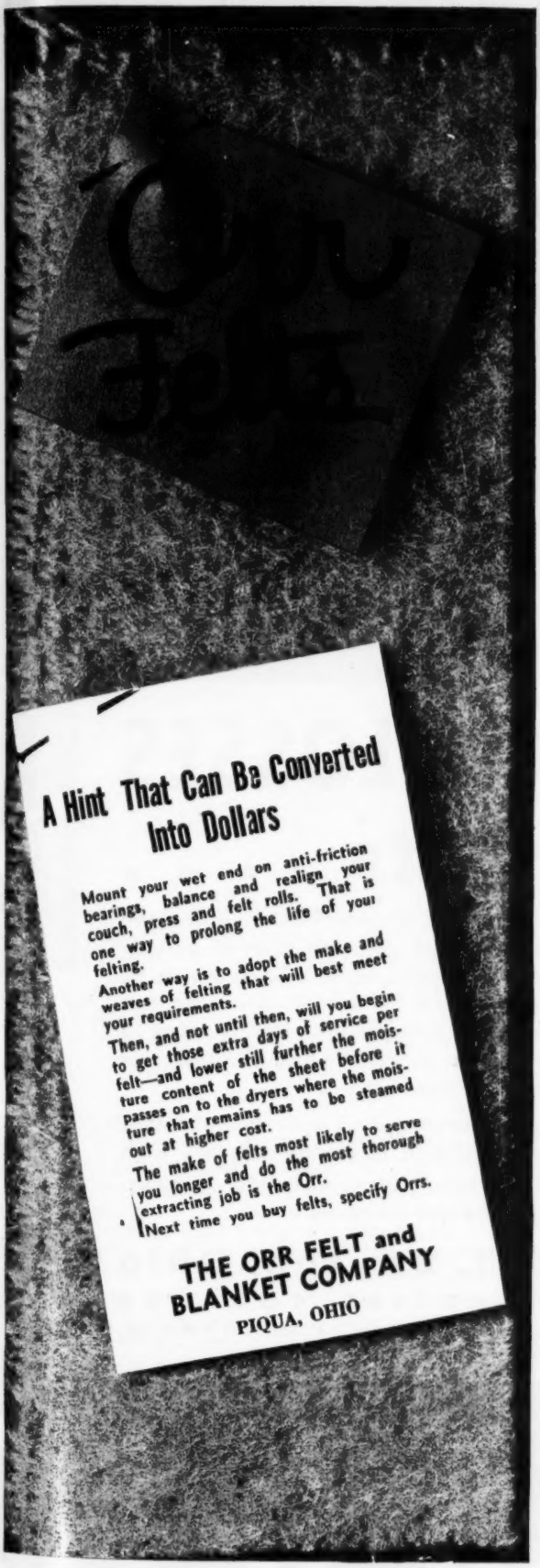
| | | | |
|---|---|---|---|
| Ground wood | 27.00 | @ | — |
| Unbleached Sulphite | 42.00 | @ | — |
| Book (Class 1) | 58.00 | @ | — |
| Writing (Class 2) | 59.00 | @ | — |
| Select (Class 3) | 60.00 | @ | — |

### Old Waste Paper
(In carload lots, f. o. b. Toronto)

| | | | |
|---|---|---|---|
| Shavings— | | | |
| White Env. Cut | 2.00 | @ | 2.30 |
| Soft White | 1.60 | @ | 1.90 |
| White Blk. News | 1.25 | @ | 1.40 |
| Book and Ledger— | | | |
| Flat Magazine and Book Stock (old) | .90 | @ | 1.00 |
| Light and Crumpled Book Stock | .80 | @ | .90 |
| Ledgers and Writings | 1.00 | @ | 1.05 |
| Manilas— | | | |
| New Manila Cut | 1.25 | @ | 1.40 |
| Printed Manilas | .50 | @ | .60 |
| Kraft | 1.00 | @ | 1.60 |
| News and Scrap— | | | |
| Strictly Overissue | .60 | @ | — |
| Strictly Folded | .50 | @ | — |
| No. 1 Mixed Paper | .40 | @ | — |

### Domestic Rags
(Price to mills, f. o. b. Toronto)

| | | | |
|---|---|---|---|
| No. 1 White Shirt Cuttings | .06 | @ | — |
| Fancy Shirt Cuttings | .02 | @ | — |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## TABLE OF CONTENTS

C. W. Boyce Analyses Paper and Pulp..... 13
Canadian Newsprint Outlook Favorable ..... 14
Pulp and Paper Expansion in B. C. ..... 14
D. Patrick Heads Miami Superintendents..... 15
Paper Industry on Up Trend..... 15
To Sell Outagamie Mill at Kaukauna ..... 15
Heads Georgia Union Bag ..... 15
Join Stevens & Thompson Paper Co. ..... 15
Executives Hold Annual Fall Meeting ..... 16
To Develop France's Pulp Industry..... 18
Government Paper Bids ..... 18
Ontario Mills Continue Fairly Active..... 21
Safety Progress in the Mills..... 21
Paper Demand Active in Philadelphia..... 22
Paper Bag Manufacturers Meet ..... 22
Taylor "Valv-Precisor" ..... 23
E. D. Jones Gets Order for Savannah..... 23
Mohawk Paper Mills Not to Close..... 23
Improved Francke Flexible Couplings ..... 24
Companies Join Technical Association ..... 24
Indianapolis Reports Improvement ..... 24
Paper Demand Better in Boston..... 25
New Conway Sleeve Clutch ..... 25
Vari-Pitch Texrope Sheave ..... 25
Construction News ..... 26
New York Carrying Out Reforestation ..... 27
Provincial Paper Makes Improvements ..... 27
Champion Issues Approved ..... 27
**Editorial** ..... 28
Consider Specialty Paper Agreement ..... 29
U. S. Newsprint Losing Ground..... 29
Large Response on Brown Co. Bonds..... 29
**Technical Section**
The Determination of Water Vapor Permeability of Cellulose Wrapping Materials.... 31
New Handbook of Chemistry ..... 39
Pulp and Paper Industry Literature Review 40
Imports of Paper and Paper Stock..... 45
**New York Market Review** ..... 47
**Miscellaneous Markets** ..... 48
**Market Quotations** ..... 48

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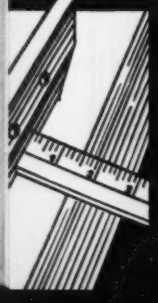

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